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## A Computer Program To Generate Equations of Motion Matrices, L217 (EOM)

Volume II: Supplemental System  
Design and Maintenance Document

R. E. Clemmons and R. I. Kroll

CONTRACT NAS1-13918  
OCTOBER 1979

**NASA**





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# A Computer Program To Generate Equations of Motion Matrices, L217 (EOM)

Volume II: Supplemental System  
Design and Maintenance Document

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*Boeing Commercial Airplane Company*  
*Seattle, Washington*

Prepared for  
Langley Research Center  
under Contract NAS1-13918



National Aeronautics  
and Space Administration

Scientific and Technical  
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1979



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## **1.0 SUMMARY**

The program L217 (EOM) is structured as a system of overlays, one main overlay with four primary overlays and their associated secondary overlays.

Input into the program is made via cards and magnetic files (tapes or disks). Output from the program consists of printed results and magnetic files containing matrices of equations of motion coefficients and aerodynamic forces.

Although L217 (EOM) serves as a module of the DYLOFLEX system, it can be operated as a standalone program. Subroutines used by L217 (EOM) include routines obtained from the standard FORTRAN library, and routines from the DYLOFLEX alternate subroutine library.

## 2.0 INTRODUCTION

The computer program L217 (EOM) was developed for use as either a standalone program or as a module of a program system called DYLOFLEX (ref. 1) (see fig. 1). The Equations of Motion program (L217) was designed to meet the DYLOFLEX contract requirements as defined in reference 2. These requirements specify the need for a program that can assemble and generate data needed to formulate the equations of motion for a flight vehicle, and the necessary aerodynamic forces that can be used in the flight loads analysis of that vehicle.

The program was designed, coded, and documented according to the programming specifications developed for DYLOFLEX<sup>1</sup>.

The objective of this volume is to aid those persons who will maintain and/or modify the program in the future. To meet this objective the following items are discussed:

- Program design and structure
- Purpose and operation of each overlay
- Input, output, and internal data bases
- Test cases

<sup>1</sup>Clemmons, R. E.: *Programming Specifications for Modules of the Dynamic Loads System to Interface With FLEXSTAB*. Boeing-NASA Contract NAS1-13918. BCS-G0701, September 1975. (internal report)



### 3.0 PROGRAM DESIGN AND STRUCTURE

The program is structured as a system of overlays, the main overlay and four primary overlays with their associated secondary overlays (see fig. 2).

Main overlay	(L217,0,0)	Program L217vc
Primary overlay	(L217,2,0)	Program STRUCT
Primary overlay	(L217,3,0)	Program FLXAIC
Primary overlay	(L217,4,0)	Program DLAIC
Primary overlay	(L217,5,0)	Program DLPRES

The main overlay named L217vc (the v and c are version and correction identifiers. See sec. 3.1) reads data cards that direct the execution of the primary overlays. It also aids communication between the primary overlays via labeled common blocks.

The 2,0 primary overlay, STRUCT, generates the equations of motion matrices that are dependent upon the structural data only. They are:

- [M<sub>1</sub>] Generalized stiffness matrix
- [M<sub>2</sub>] Generalized damping matrix
- [M<sub>3</sub>] Generalized inertia matrix

The remaining primary overlays generate the equations of motion matrices that are dependent upon the aerodynamic data. They are:

- [M<sub>4</sub>] Generalized aerodynamic stiffness matrix
- [M<sub>5</sub>] Generalized aerodynamic damping matrix
- {f<sub>g</sub>} The distance(s) from the gust reference point to the control point(s) of the gradual penetration gust zones.
- [ $\tilde{\phi}$ ] The generalized gust forcing function matrix

The 3,0 primary overlay, FLXAIC, generates the aerodynamic equations of motion that are based upon the FLEXSTAB (ref. 3) AIC (aerodynamic influence coefficient) matrices.

The 4,0 primary overlay, DLAIC, generates the aerodynamic equations of motion based upon Doublet Lattice (L216) (ref. 4) AIC matrices.

The 5,0 primary overlay, DLPRES, generates the aerodynamic equations of motion based upon generalized forces and unsteady pressures from Doublet Lattice (ref. 4).

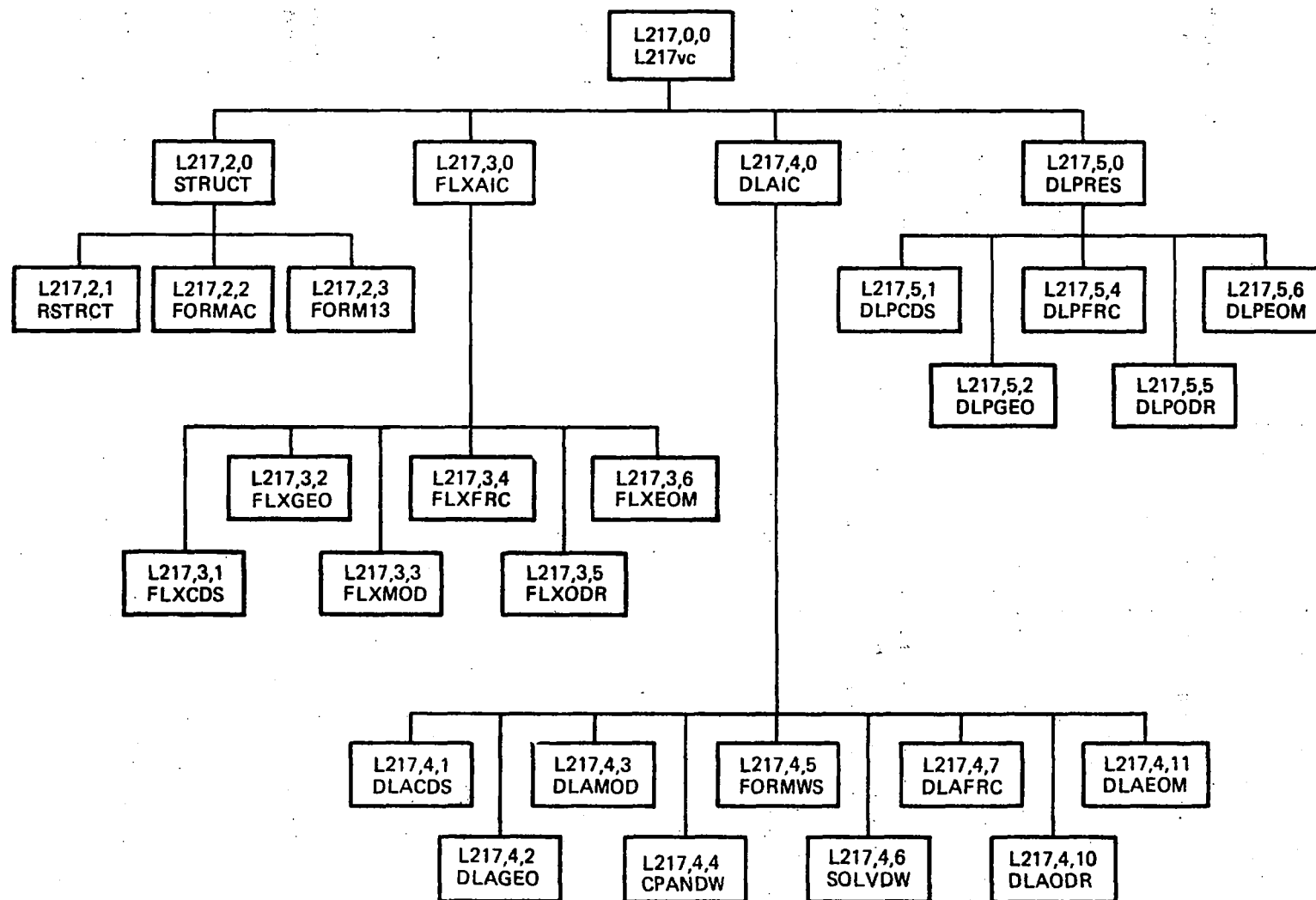


Figure 2. —Overlay Structure of L217 (EOM)

Although L217 (EOM) serves as a module of the DYLOFLEX system, it is operated as a standalone program. When the program is run by itself, it becomes the user's responsibility to generate input data in the format required by the program. (See vol. I of this document for a description of the required data and formats.) L217 (EOM) is heavily dependent upon data generated prior to its execution. Figure 3 displays the different files, which L217 (EOM) may require, according to user specified options. The following programs produce or read the files displayed in figure 3.

<b>Program</b>	<b>Reference number</b>
<b>FLEXSTAB</b>	<b>3</b>
<b>L216(DUBFLX)</b>	<b>4</b>
<b>L215(INTERP)</b>	<b>5</b>
<b>L221(TEV156)</b>	<b>6</b>
<b>L219(EQMOD)</b>	<b>7</b>
<b>L218(LOADS)</b>	<b>8</b>

The program requires subroutines which are not part of the L217 (EOM) code. Some routines are automatically obtained from the standard CDC FORTRAN library when the program is loaded. Others, however, are stored in the DYLOFLEX alternate subroutine library that must be declared at the time of loading. Subsequent sections describe each overlay separately and contain tables displaying the routines called and the library in which they are located. All subroutines have one entry point.

This volume describes the program in a macro sense. A more detailed discussion appears in the comments contained in the program source code. Each routine contains a preface describing the routine's purpose, author, analytical steps, modification history, input data, output data, glossary of variables, and a list of other routines called. Embedded within the executable code are comments labelling each section and explaining logical branches.

### **3.1 OVERLAY(L217,0,0), L217vc**

The main overlay of L217 (EOM) is named L217vc where:

- v** Is a letter indicating the program version
- c** Is an integer indicating the correction set applied to the v version

#### **Purpose of L217vc**

L217vc performs certain bookkeeping tasks, directs the execution of the primary overlays, and aids communication between primary overlays via labeled common blocks.

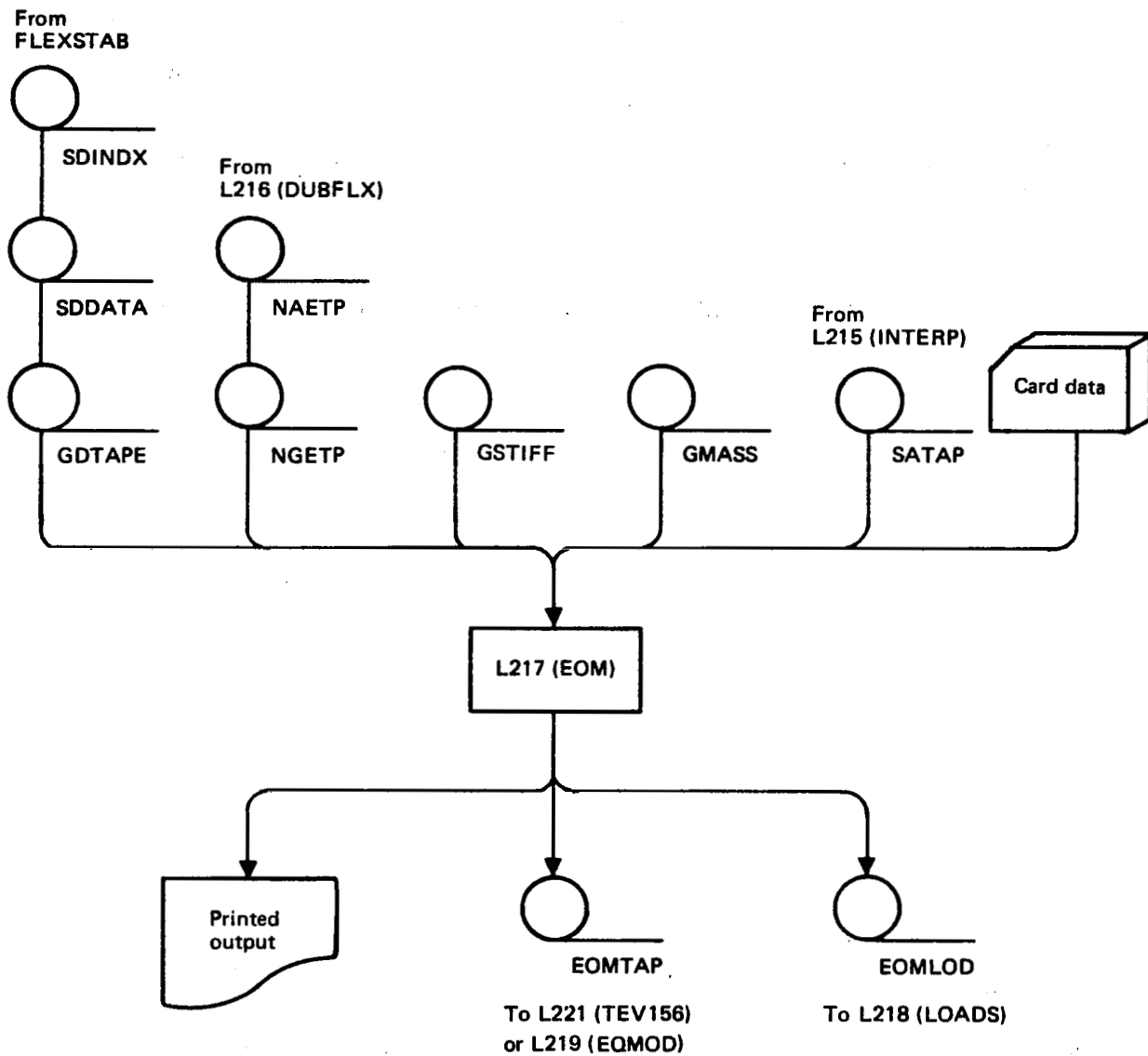


Figure 3. — L217 (EOM) Communication Via External Files

## Analytical Steps of L217vc

The L217vc performs its tasks in the following steps:

1. The subroutine PRGBEG is called to place the program header on the printed output.
2. A data card is read. It must begin with \$EOM to ensure that the input file is correctly positioned. If it does not contain \$EOM, execution is terminated.
3. A program directive card is read, printed, interpreted, and acted upon according to the following logic:
  - a. If the keyword is \$TITLE jump to step 3 again.
  - b. If the keyword is \$NONSTOP set the nonstop switch and jump to step 3 again.
  - c. If the keyword is \$STRUCTURAL, jump to step 4.
  - d. If the keyword is \$AERO followed by FLEXSTAB jump to step 5.
  - e. If the keyword is \$AERO followed by DOUB...AIC jump to step 6.
  - f. If the keyword is \$AERO followed by DOUB...PRES jump to step 7.
  - g. If the keyword is \$QUIT jump to step 8.
4. Overlay (L217,2,0), STRUCT is called. When it is finished, control returns to step 3.
5. Overlay (L217,3,0), FLXAIC is called. When it is finished, control returns to step 3.
6. Overlay (L217,4,0), DLAIC, is called. When it is finished, control returns to step 3.
7. Overlay (L217,5,0), DLPRES, is called. When it is finished, control returns to step 3.
8. Subroutine PRGEND is called to place the program termination message on the printed output file, and the execution is terminated.

If errors were detected, the program jumps to step 8.

The macro flow chart of this overlay is shown in figure 4.

The routines called are displayed in table 1.

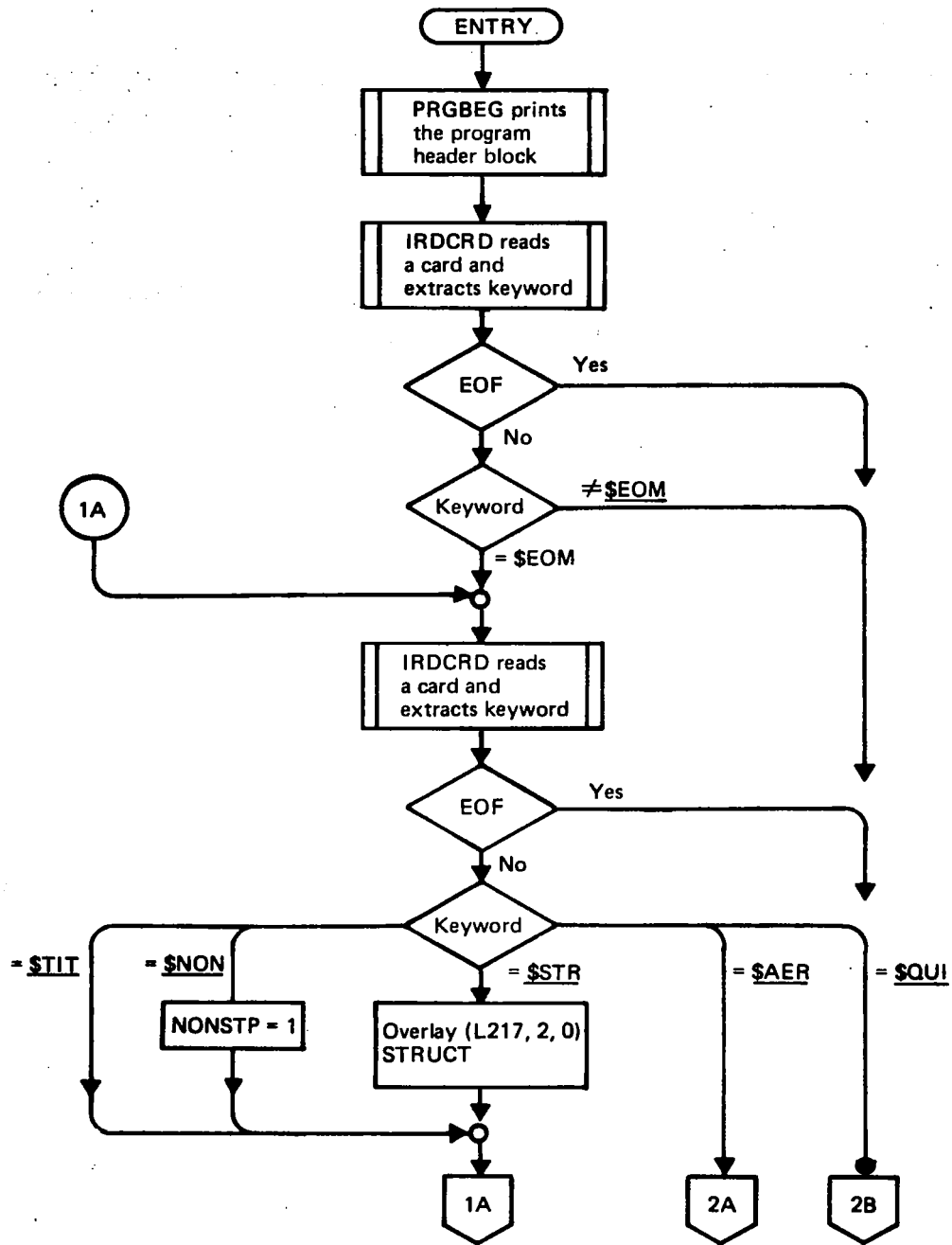


Figure 4. — Macro Flow Chart of Overlay (L217, 0, 0), L217 vc

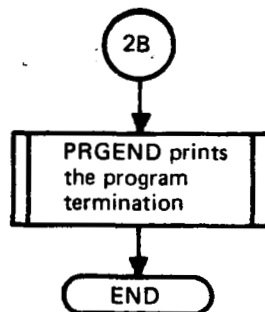
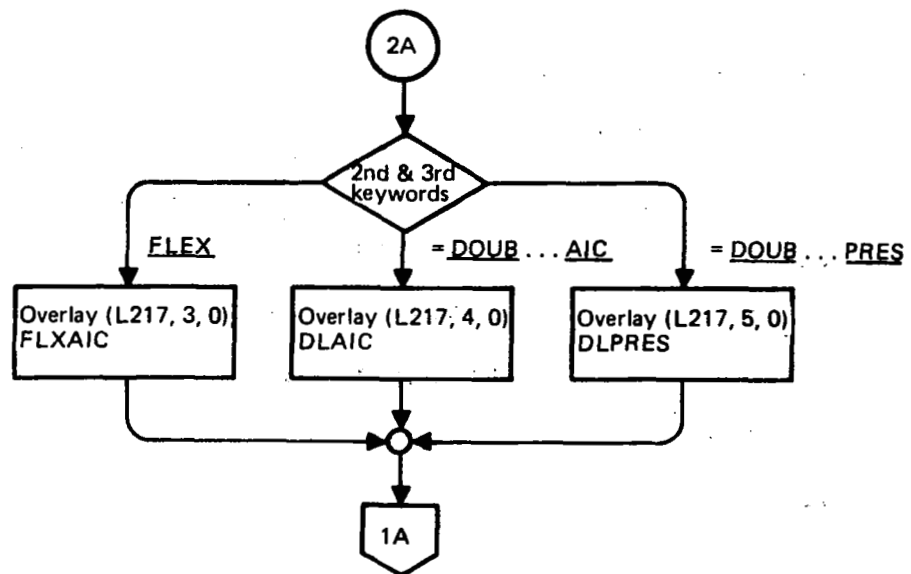


Figure 4. — (Concluded)

*Table 1. — Routines Called By L217vc*

OVERLAY (L217,0,0)

PROGRAM L217vc

-----  
DLAIC - OVERLAY (L217,4,0)

DLPRES - OVERLAY (L217,5,0)

FLXAIC - OVERLAY (L217,3,0)

FNDKEY+

IRDCRD+

PFGBEG+

PRGEND+

RETURNF+

STRUCT - OVERLAY (L217,2,0)

+ indicates a routine obtained from  
the DYLOFLEX alternate subroutine library.

All others are local to L217 (EOM).

## I/O Devices of L217vc

The L217vc reads program directive cards and writes them on the printed output file. All other I/O accomplished by L217 (EOM) is done in lower level overlays.

### 3.2 OVERLAY(L217,2,0), STRUCT

#### Purpose of STRUCT

The L217 (EOM)'s first primary overlay is named STRUCT. STRUCT generates the equations of motion matrices  $[M_1]$ ,  $[\dot{M}_2]$ , and  $[M_3]$ .

#### Analytical Steps of STRUCT

STRUCT performs its task in the following steps:

1. Initialize the error count and print a message indicating that STRUCT is being executed.
2. Call overlay (L217,2,1) RSTRUCT to read the card input data directing the structural data processing.
3. If control surface freedoms are to be added to the existing generalized mass and stiffness matrices, call overlay (L217,2,2), FORMAC, to form the matrices  $[A]$  and  $[C]$ . (See sec. 3.2.2.)
4. Call overlay (L217,2,3), FORM13, to generate the matrices  $[M_1]$ ,  $[\dot{M}_2]$ , and  $[M_3]$  and save them on the temporary storage file named S2L217.
5. Print a message indicating that STRUCT is finished and return to the main overlay, L217.

If errors were detected in the secondary overlays, the program jumps to step 5.

The macro flow chart of this overlay is shown in figure 5.

The routines called are displayed in table 2.

#### I/O Devices of STRUCT

STRUCT prints two messages on the output file; NOW IN STRUCT...and STRUCT IS FINISHED... All other file communication in STRUCT is performed by its secondary overlays. Figure 6 shows the files providing input and output to STRUCT's overlays.

In subsections 3.2.1 through 3.2.3, the matrices read from and written onto each file are listed. (See sec. 6.4 of vol. I, *Engineering and Usage*, for detailed description of the format and content of files used for external communication.) Section 3.6.3 of this volume contains the same information for files used only within L217 (EOM) for temporary storage.

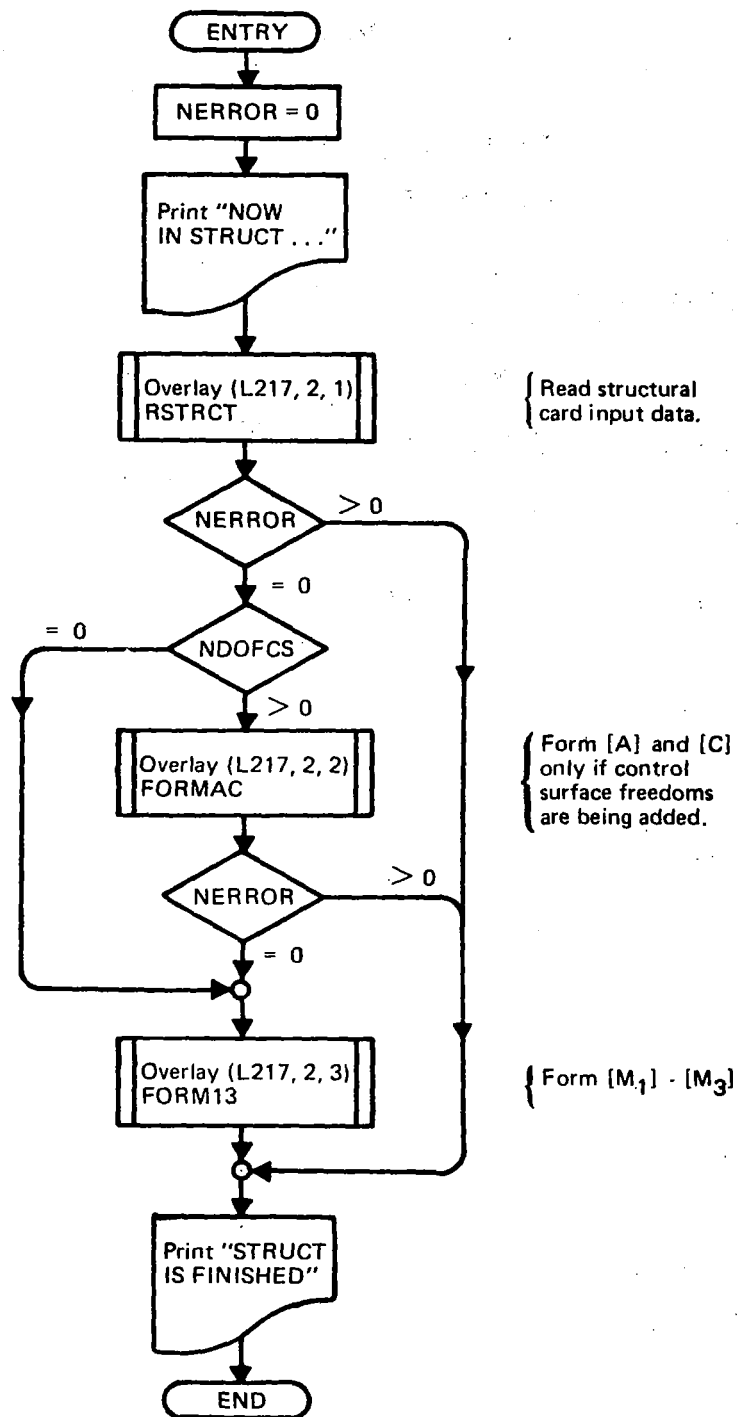


Figure 5. — Macro Flow Chart of Overlay (L217, 2, 0), STRUCT

**Table 2. — Routines Called by STRUCT**

**OVERLAY (L217, 2, 0)**

**PROGRAM STFUCT**

---

**FORMAC - OVERLAY (L217, 2, 2)**

**FORM13 - OVERLAY (L217, 2, 3)**

**RSTRUCT - OVERLAY (L217, 2, 1)**

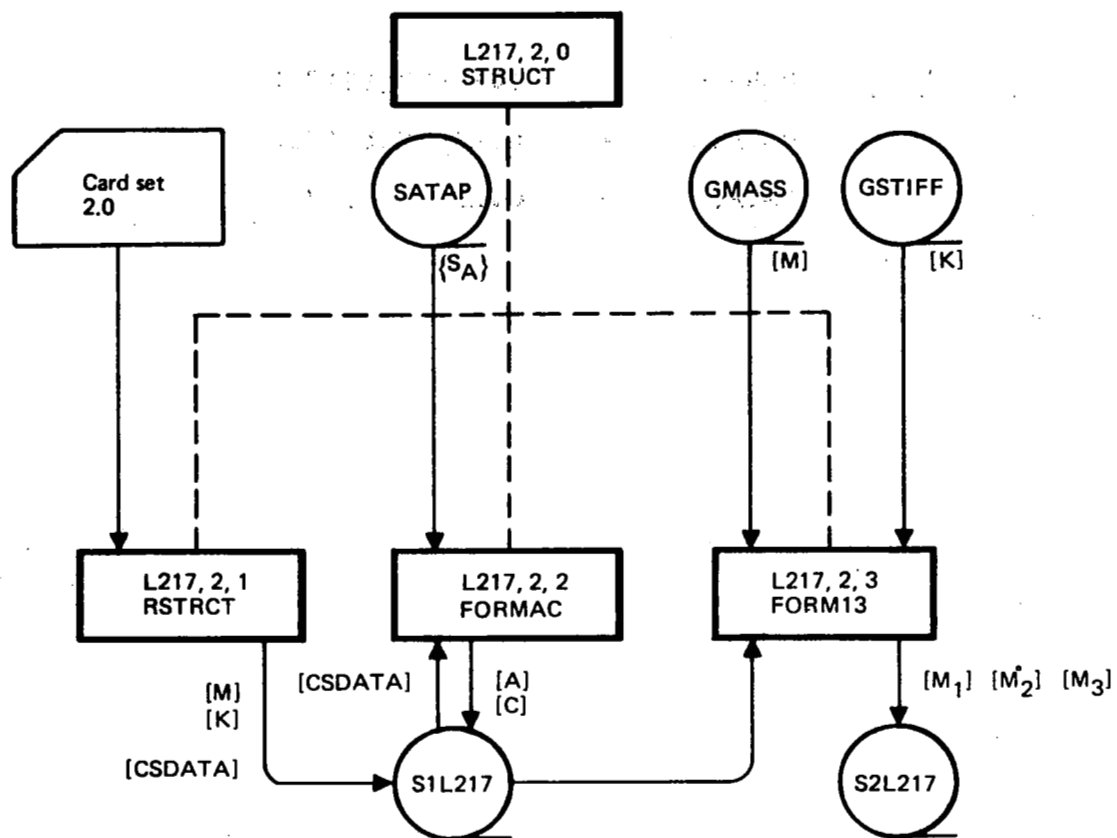


Figure 6. — Files Providing Input/Output to STRUCT Overlays

### **3.2.1 OVERLAY(L217,2,1), RSTRCT**

#### **Purpose of RSTRCT**

RSTRCT reads the card input data directing the processing of structural data. Options and constants are stored in labelled common blocks for later use. If either the generalized mass or generalized stiffness matrix is read from cards, it is written onto the temporary storage file named S1L217 for later retrieval by overlay (L217,2,3), FORM13.

The macro flow chart of this overlay is shown in figure 7.

The routines called are displayed in table 3.

#### **I/O Devices of RSTRCT**

RSTRCT reads card images from the input file and prints them on the output file along with descriptive comments and any necessary diagnostics.

When either the generalized mass matrix or generalized stiffness matrix is input on cards, RSTRCT writes them onto the temporary storage file named S1L217 (see fig. 6).

### **3.2.2 OVERLAY(L217,2,2), FORMAC**

#### **Purpose of FORMAC**

FORMAC is called to generate the matrices  $[A]$  and  $[C]$ . The two matrices will become partitions of  $[M_3]$ , the generalized mass matrix. They represent control-surface, generalized coordinates being added to the original structural data.

#### **Analytical Steps of FORMAC**

FORMAC generates  $[A]$  and  $[C]$  in the following steps:

1. Open the files ICSTPE (containing the control surface data) and SATAP (the file of interpolation arrays). Set aside storage for the arrays  $[\phi]$ ,  $[\dot{MCS}]$ , and  $[CSDATA]$ .

Repeat steps 2 through 5 for each control surface adding freedoms;  $ICS = 1$ , NCSEF.

2. Read the nodal data for control surface IS from S1L217.
3. Call BLDMCS to add the control surface mass and inertia data to  $[\dot{MCS}]$ .
4. Read the interpolation array  $\{SA\}$  for the control surface from SATAP.
5. Interpolate for the modal deflection and/or slopes as requested and build the matrix  $[\phi]$ .

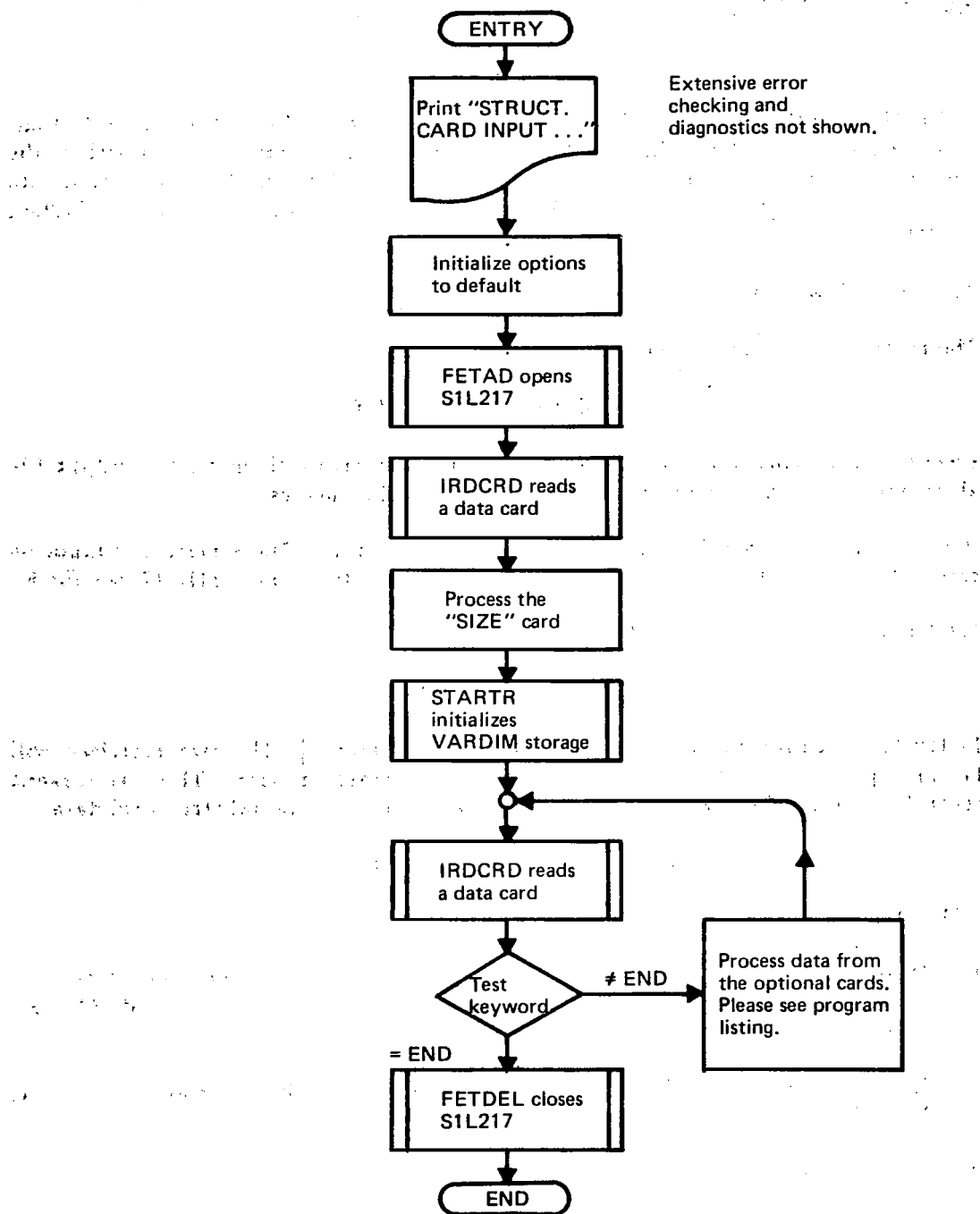


Figure 7. — Macro Flow Chart of Overlay (L217, 2, 1), RSTRCT

*Table 3. — Routines Called by RSTRCT*

OVERLAY (L217, 2, 1)

PROGRAM RSTRCT

---

DELETR+

FETAD+

FETDEL+

INITIR+

IRDCRD+

MATCRD

NAMFIL+

KDCSCD

IRDCRD+

SETMFL

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library.

6. Close the files ICSTPE and SATAP.
7. Initialize the file S1L217 and generate the temporary array.

$$[PCSTM] = [\phi_{CS}]^T [\overset{\circ}{M}CS]$$

8. Generate  $[A]$  and write it on S1L217.

$$[A] = [PCSTM] [\phi_{ST}].$$

9. Generate  $[C]$  and write it on S1L217.

$$[C] = [PCSTM] [\phi_{CS}].$$

10. Return to the calling program.

The macro flow chart of this overlay is shown in figure 8.

The routines called are displayed in table 4.

### I/O Devices of FORMAC

FORMAC's communication via external files is displayed in figure 6.

FORMAC reads from the files:

S1L217      the control surface nodal data written there by RSTRCT

SATAP      the modal interpolaton array(s) specified by surface number on card input

FORMAC writes onto the file:

S1L217      the matrices  $[A]$  and  $[C]$

### 3.2.3 OVERLAY(L217,2,3), FORM13

#### Purpose of FORM13

FORM13 generates the structural equations of motion ( $[M_1]$ ,  $[M_2]$ , and  $[M_3]$ ) and saves them on the temporary storage file named S2L217.

#### Analytical Steps of FORM13

FORM13 performs its tasks in the following steps:

1. Initialize the output file S2L217 and variably dimensioned array storage. Initialize the array  $[\dot{M}_2]$ , if structural damping was specified by the user.

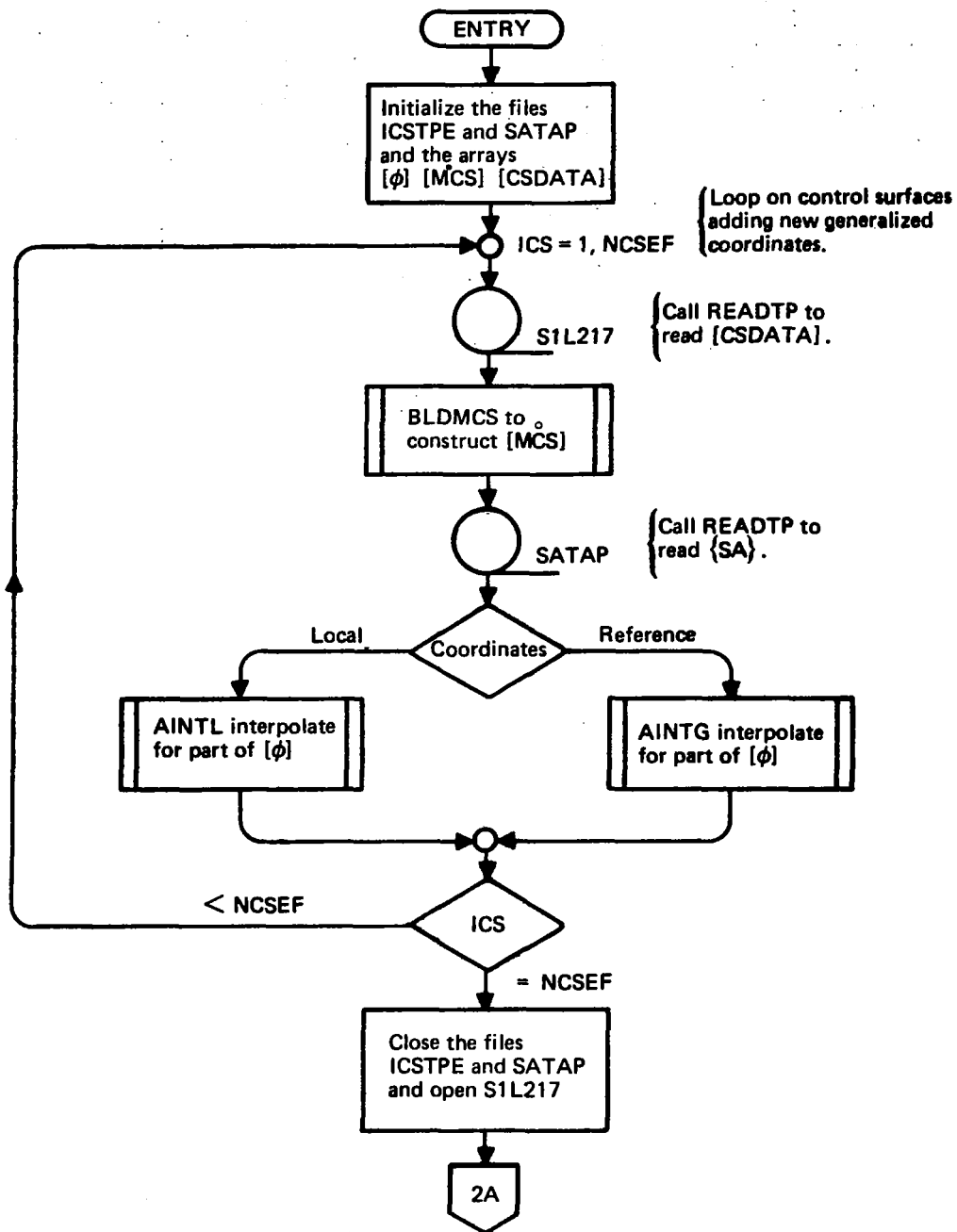


Figure 8. — Macro Flow Chart of Overlay (L217,2,2), FORMAC

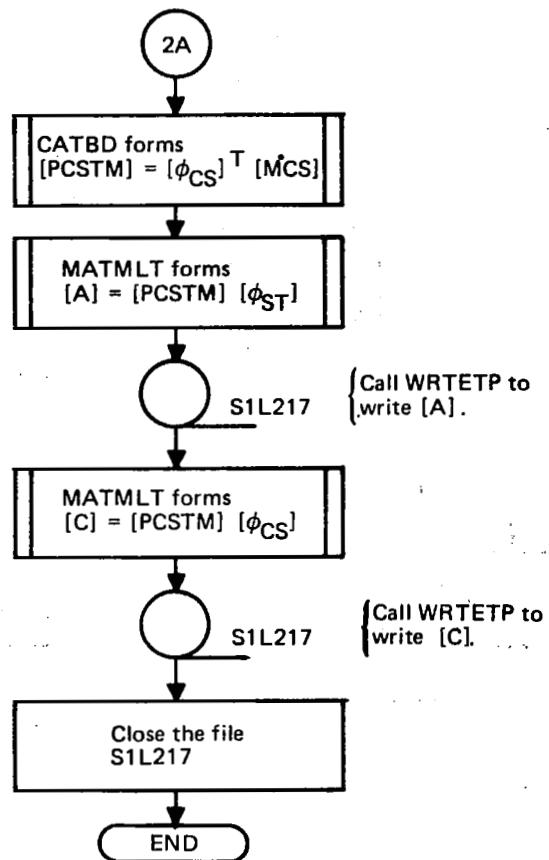


Figure 8. — (Concluded)

*Table 4. — Routines Called by FORMAC*

OVERLAY (L217,2,2)

PROGRAM FORMAC

---

AINTG+

AINTL+

BLDMCS

CATBD

DELETR+

FETAD+

FETDEL+

INITIR+

MATMLT

PRINTM+

READTP+

SETMFL

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate suroutine library.

2. Initialize  $[M_1]$ , read the generalized stiffness matrix into its upper left partition, scale if requested, and write  $[M_1]$  onto the file S2L217.
3. If structural damping was requested, read the damping factors into  $[\dot{M}_2]$  and multiply them by the square root of the corresponding diagonal elements of  $[M_1]$ .
4. Erase  $[M_1]$ , initialize  $[M_3]$ , and read the generalized mass matrix into the upper left partition.
5. If structural damping was requested, multiply the elements of  $[\dot{M}_2]$  by the square root of the corresponding diagonal elements of  $[M_3]$ , and write  $[\dot{M}_2]$  onto S2L217.
6. Read the matrices  $[A]$  and  $[C]$  from S1L217 and store in  $[M_3]$  as shown in the following equation, and write  $[M_3]$  onto S2L217.

$$[M_3] = \begin{bmatrix} [M][A]^T \\ [A][C] \end{bmatrix}$$

Note:  $[A]$  and  $[C]$  are present only when new generalized coordinates are being added.

7. Write an end of file on S2L217, close the file, and return to the calling program.

The macro flow chart of this overlay is shown in figure 9.

The routines called are displayed in table 5.

### I/O Devices of FORM13

FORM13's communication via files is displayed in figure 6.

FORM13 reads from the files:

- |               |  |
|---------------|--|
| <b>GMASS</b>  | Generalized mass matrix (if not read from cards).  |
| <b>GSTIFF</b> | Generalized stiffness matrix (if not read from cards).   |
| <b>S1L217</b> | Matrices $[A]$ and $[C]$ (if control surface freedoms are being added) and the matrices $[M]$ and $[K]$ if they were read from cards by RSTRUCT. |

FORM13 writes onto the file:

- |               |  |
|---------------|--|
| <b>S2L217</b> | the matrices $[M_1]$ , $[M_2]$ , and $[M_3]$ |
|---------------|--|

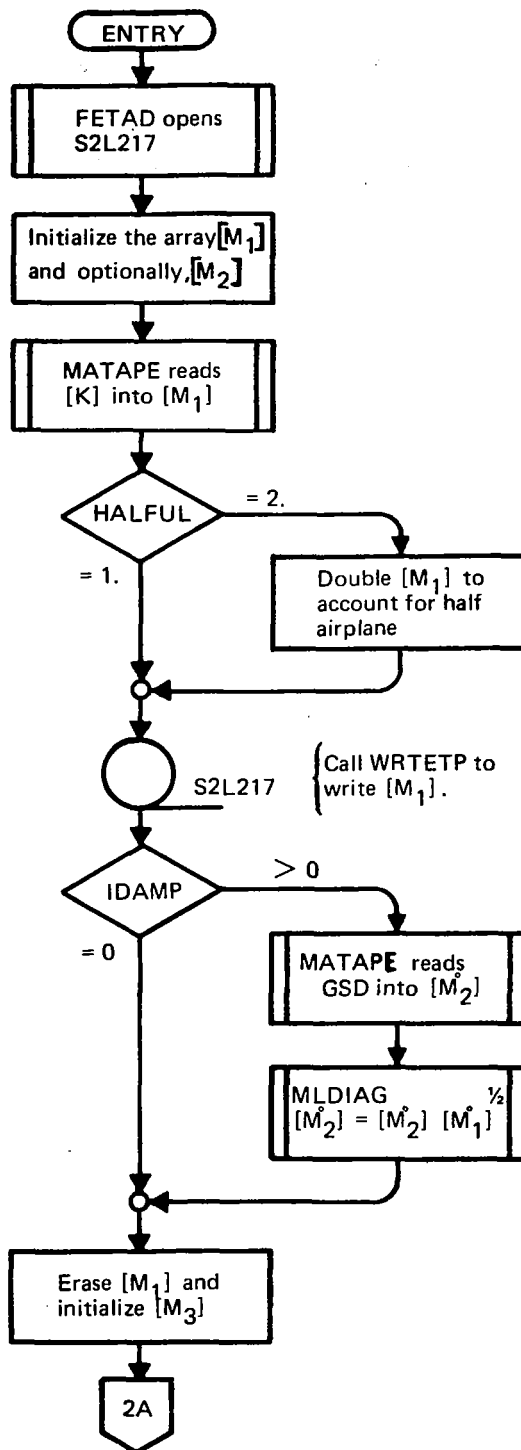


Figure 9. — Macro Flow Chart of Overlay (L217, 2, 3), FORM13

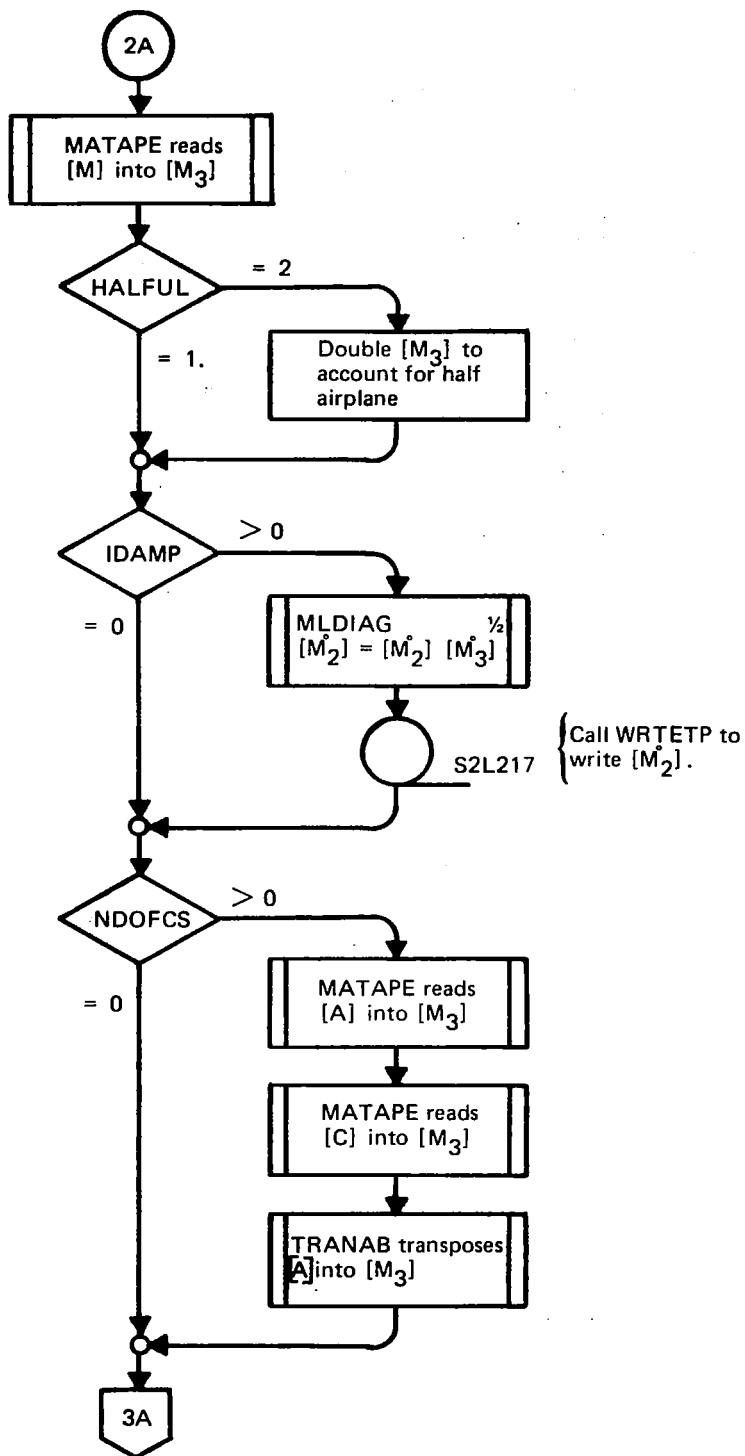
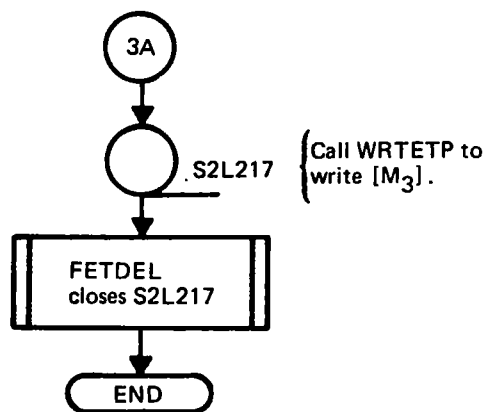


Figure 9. — (Continued)



*Figure 9. – (Concluded)*

Table 5. — Routines Called by FORM13

OVERLAY (L217, 2, 3)

PROGRAM FORM13

---

DELETR+

FETAD+

FETDEL+

INITIR+

MATAPE

{ FETAD+

FETDEL+

FEADTP+

MLDIAG

PRINTM+

SCLMLT+

SETMFL

STARTR+

TRANAE

WFTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library.

### **3.3 OVERLAY(L217,3,0), FLXAIC**

#### **Purpose of FLXAIC**

FLXAIC generates aerodynamic force matrices and equations of motion coefficient matrices based upon the AIC matrices ( $A_{p\theta}$ ) generated by FLEXSTAB (ref. 3).

#### **Analytical Steps for FLXAIC**

FLXAIC performs its task in the following steps:

1. Initialize the error count and print a message indicating that FLXAIC is being executed.
2. Call overlay (L217,3,1), FLXCDS, to read FLXAIC card input data.
3. Call overlay (L217,3,2), FLXGEO, to read geometry data from the FLEXSTAB file known as GDTAPE.
4. Call overlay (L217,3,3), FLXMOD, to interpolate for the modal data required by FLXAIC.
5. Call overlay (L217,3,4), FLXFRC, to calculate the aerodynamic forces at all force points.
6. Call overlay (L217,3,5), FLXODR, to sort the aerodynamic forces and prepare the output file known as EOMLOD.
7. Call overlay (L217,3,6), FLXEOM, to generate the aerodynamic equations of motion matrices and write them onto the file EOMTAP after the structural equations of motion matrices.
8. Print a message indicating that FLXAIC is finished and return to the main overlay, L217.

If errors were detected in the secondary overlays, the program jumps to step 8.

The macro flow chart of this overlay is shown in figure 10.

The routines called are displayed in table 6.

The equations solved by FLXAIC are summarized as follows:

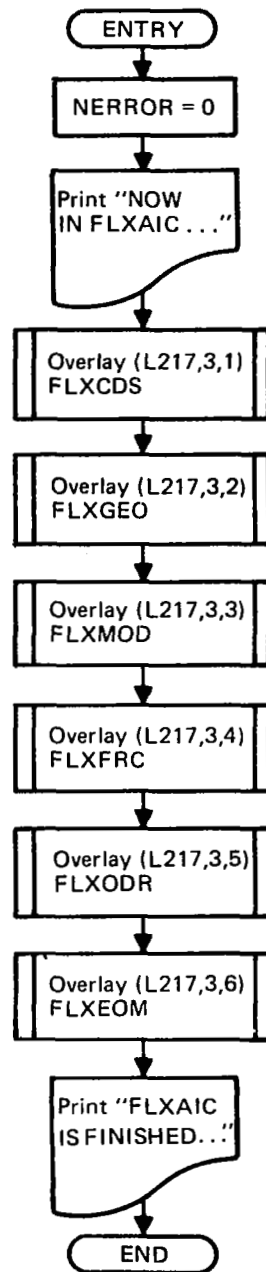


Figure 10. — Macro Flow Chart of Overlay (L217,3,0), FLXAIC

Table 6. — Routines Called by FLXAIC

OVERLAY (L217,3,0)

PROGRAM FLXAIC

---

FLXCDS - OVERLAY (L217,3,1)

FLXGEO - OVERLAY (L217,3,2)

FLXMOD - OVERLAY (L217,3,3)

FLXFRC - OVERLAY (L217,3,4)

FLXODR - OVERLAY (L217,3,5)

FLXEOM - OVERLAY (L217,3,6)

FETAD+

FETDEL+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

$$\begin{aligned}
[F_1] &= -q [F\ddot{A}C][\ddot{\Sigma}^*][\ddot{A}][AIC][\phi'_{CP}] \\
[F_2] &= -\frac{q}{V} [F\ddot{A}C][\ddot{\Sigma}^*][\ddot{A}][AIC][\phi_{CP}] \\
[FG] &= q [F\ddot{A}C][\ddot{\Sigma}^*][\ddot{A}][AIC][R\ddot{G}][G\ddot{C}^*]
\end{aligned}$$

$$\begin{aligned}
[M_4] &= -[\phi_{FP}]^T [\ddot{S}\ddot{F}] [F_1] \\
[M_5] &= -[\phi_{FP}]^T [\ddot{S}\ddot{F}] [F_2] \\
[\tilde{\phi}] &= [\phi_{FP}]^T [\ddot{S}\ddot{F}] [FG]
\end{aligned}$$

An \* indicates that the matrix product is not performed in the normal fashion.

For instance,  $[\Sigma]$  is actually stored as NTOTF x four but in the matrix multiply, it acts like a matrix of size NAFP x NTOTF. The  $[GC]$  is stored as NACP x one but it acts like a matrix NACP x NGCP in the matrix multiply. (See description of the file S1L217 just ahead of fig. 36.)

### I/O Devices of FLXAIC

FLXAIC prints two messages on the output file; NOW IN FLXAIC...and FLXAIC IS FINISHED... All other file communication in FLXAIC is performed by its secondary overlays. Figure 11 shows the files used in FLXAIC's secondary overlays.

In subsections 3.3.1 through 3.3.6 the matrices read from and written onto each file are listed. (See secs. 6.4 to 6.5 of vol. I, *Engineering and Usage*, for detailed descriptions of the format and content of the files used for external communication.) Section 3.6.3 of this volume contains the same information for L217 (EOM)'s temporary scratch files.

#### 3.3.1 OVERLAY(L217,3,1), FLXCDS

##### Purpose of FLXCDS

FLXCDS reads the card input data directing the L217 (EOM) generation of equations of motion matrices from FLEXSTAB AIC matrices. (See card set 3.0 in vol. I of this document, *Engineering and Usage*.) Options, constants, and file names are stored in labelled common blocks for later use. The card data defining the correspondence between FLEXSTAB bodies (slender bodies and thin bodies), and the L215 (INTERP) modal interpolation surfaces are stored in the arrays {BODTAP} and {ICSTAB} and written onto the temporary storage file S1L217.

The macro flow chart of this overlay is shown in figure 12.

The routines called are displayed in table 7.

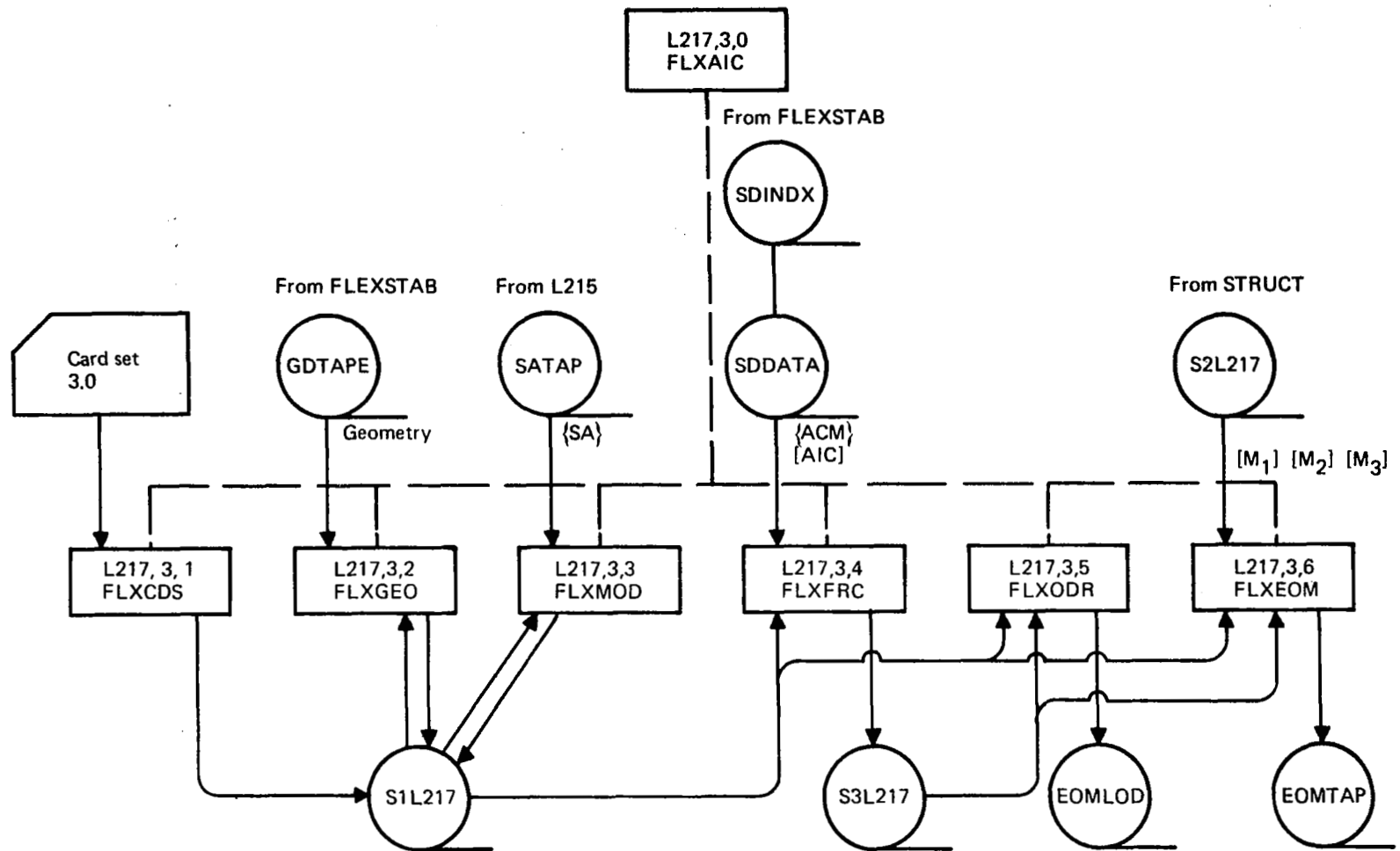


Figure 11. — Files Providing Input/Output to FLXAIC Overlays

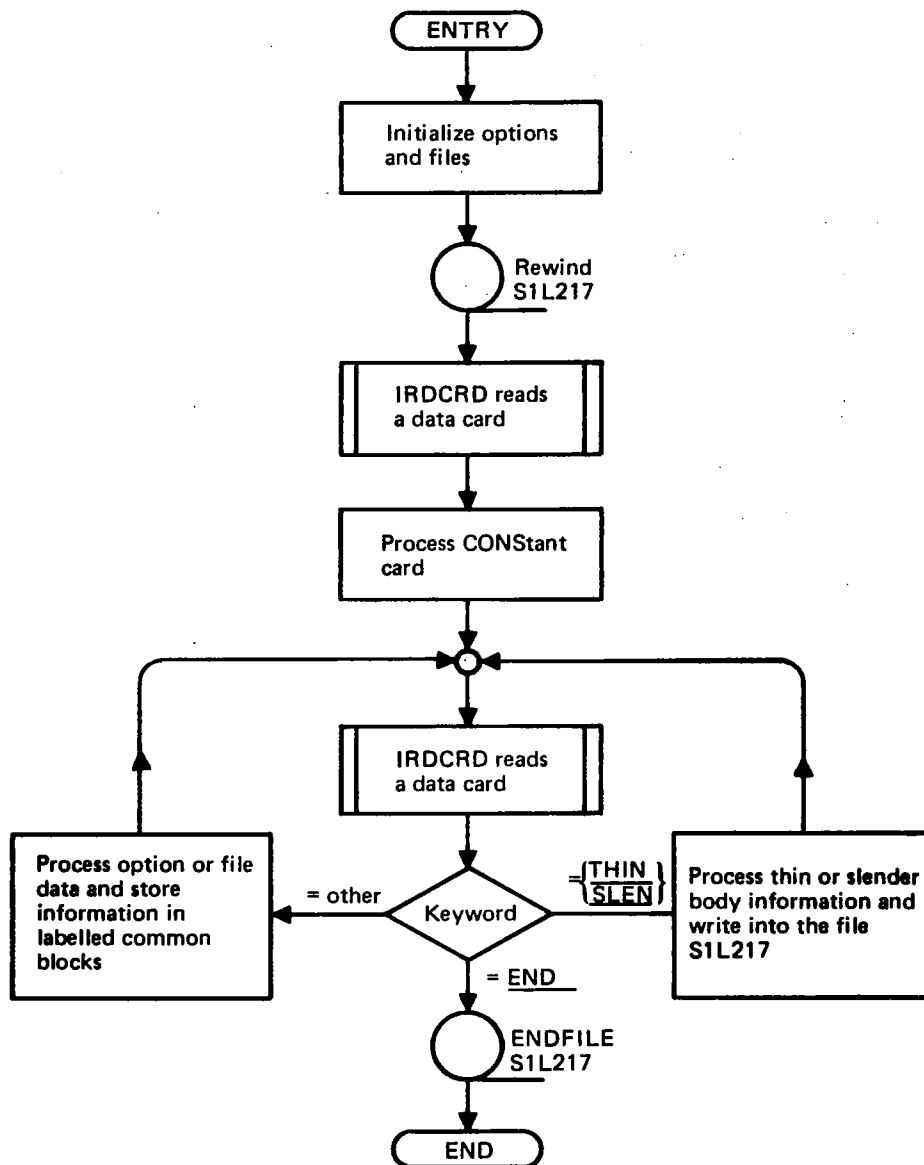


Figure 12. — Macro Flow Chart of Overlay (L217, 3, 1), FLXCDS

*Table 7. — Routines Called by FLXCDS*

OVERLAY (L217, 3, 1)

PROGRAM FLXCDS

---

FNDKEY+

IRDCRD+

IFQL+

NAMFIL+

WRTETP+

+ indicates a routine in the DYLOFLEX  
alternate subroutine library

## **I/O Devices Used**

FLXCDS reads card set 3 from the input file and prints the card images on the output file with descriptive comments and any necessary diagnostics.

FLXCDS writes onto the file:

S1L217     Arrays {IBDTAB} and {ICSTAB} (see sec. 3.6.3 for contents)

### **3.2.2 OVERLAY(L217,3,2), FLXGEO**

#### **Purpose of FLXGEO**

FLXGEO reads the FLEXSTAB geometry data from the file GDTAPE, combines it with the card input data saved on S1L217, and prepares the geometry data required throughout FLXAIC. The matrices produced are written onto the file S1L217 (overwriting the arrays of card input data). See section 3.6.2 for a description of the file's contents and format.

The macro flow chart of this overlay is shown in figure 13.

The routines called are displayed in table 8.

#### **I/O Devices of FLXGEO**

FLXGEO reads from the files:

S1L217     Arrays {BODTAB} and {ICSTAB} written there by FLXCDS

GDTAPE     FLEXSTAB geometry data (see sec. 6.4.6 of vol. I)

FLXGEO writes onto the file:

S1L217     Geometry matrices and arrays directing the FLXAIC processing (see sec. 3.6.3 for content and format)

### **3.3.3 OVERLAY(L217,3,3), FLXMOD**

#### **Purpose of FLXMOD**

FLXMOD uses the SA arrays read from the file SATAP (produced by L215 (INTERP)) to find the following matrices:

- [ $\phi_{CP}$ ]     Modal deflections at the aero control points (thin body box quarter chord and slender body segment midpoints)
- [ $\phi'_{CP}$ ]     Modal slopes at the aero control points
- [ $\phi_{FP}$ ]     Modal deflections at the aero force points

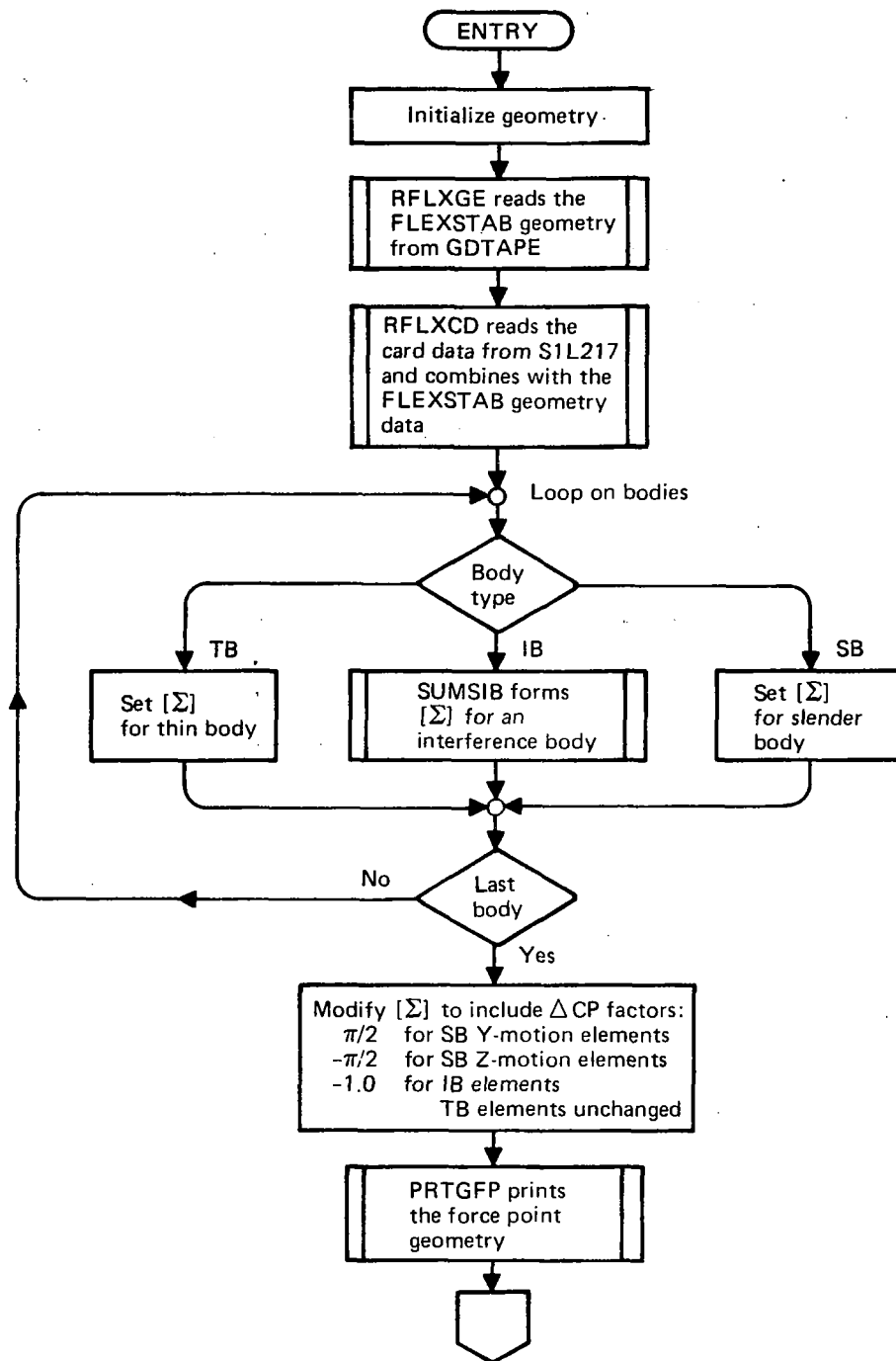


Figure 13. — Macro Flow Chart of Overlay (L217, 3, 2), FLXGEO

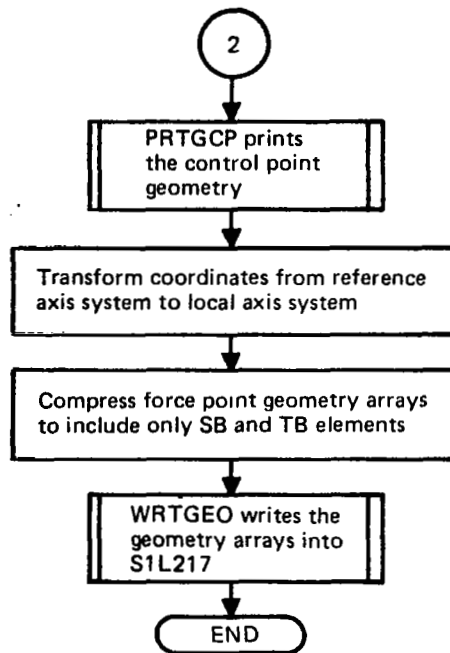


Figure 13. — (Concluded)

Table 8. — Routines Called by FLXGEO

OVERLAY (L217, 3, 2)

PROGRAM FLXGEO

GTOLT+

PRTGCP

PRTGFP

RFLXCD	{	IFQL+
		READTP+
RFLXGE	{	FETAD+
		FETDEL+
		FSF+
		GZONES

SUMSIB

WFTGEO	WRTETP+
--------	---------

+ indicates a routine in the DYLOFLEX  
alternate subroutine library.

The DYLOFLEX library routine AINTL is called to interpolate for the modal data using the SA array(s) from SATAP and the nodal coordinates read from S1L217.

The macro flow chart of this overlay is in figure 14.

The routines called are displayed in table 9.

### I/O Devices of FLXMOD

FLXMOD reads from the files:

S1L217	The matrices	
	{SURFTB}	} all are described in section 3.6.3
	{IPNSRF}	
	{X}	
	{Y}	
	{IPNSCP}	
	{XCP}	
	{YCP}	

SATAP SA arrays from L215 (INTERP). (see vol. I of this document and ref. 5 for a description)

FLXMOD writes onto the file:

S1L217 Matrices  $[\phi_{CP}]$ ,  $[\phi'_{CP}]$ , and  $[\phi_{FP}]$

Note that if the number of modes is greater than 20 the matrices are partitioned and the trio is repeated as often as necessary to include all modes.

### 3.3.4 OVERLAY(L217,3,4), FLXFRC

#### Purpose of FLXFRC

FLXFRC generates the aerodynamic forces matrices  $[F_1]$ ,  $[F_2]$ , and  $[FG]$  where:

$$[F_1] = -q [F\ddot{A}C] [\ddot{\Sigma}]^* [\ddot{A}] [AIC] [\phi'_{CP}]$$

$$[F_2] = -\frac{q}{V} [F\ddot{A}C] [\ddot{\Sigma}]^* [\ddot{A}] [AIC] [\phi_{CP}]$$

$$[FG] = q [F\ddot{A}C] [\ddot{\Sigma}]^* [\ddot{A}] [AIC] [\ddot{R}G] [\ddot{G}C]^*$$

If the number of modes exceeds 20, the matrices  $[\phi_{CP}]$  and  $[\phi'_{CP}]$  are read in partitions, and the matrices  $[F_1]$  and  $[F_2]$  are generated in partitions with the same number of columns.

The \* above the matrices  $[\ddot{\Sigma}]$  and  $[\ddot{G}C]$  indicates that the operation performed is not a normal matrix multiply. Both matrices are described in section 3.6.3 with the file S1L217.

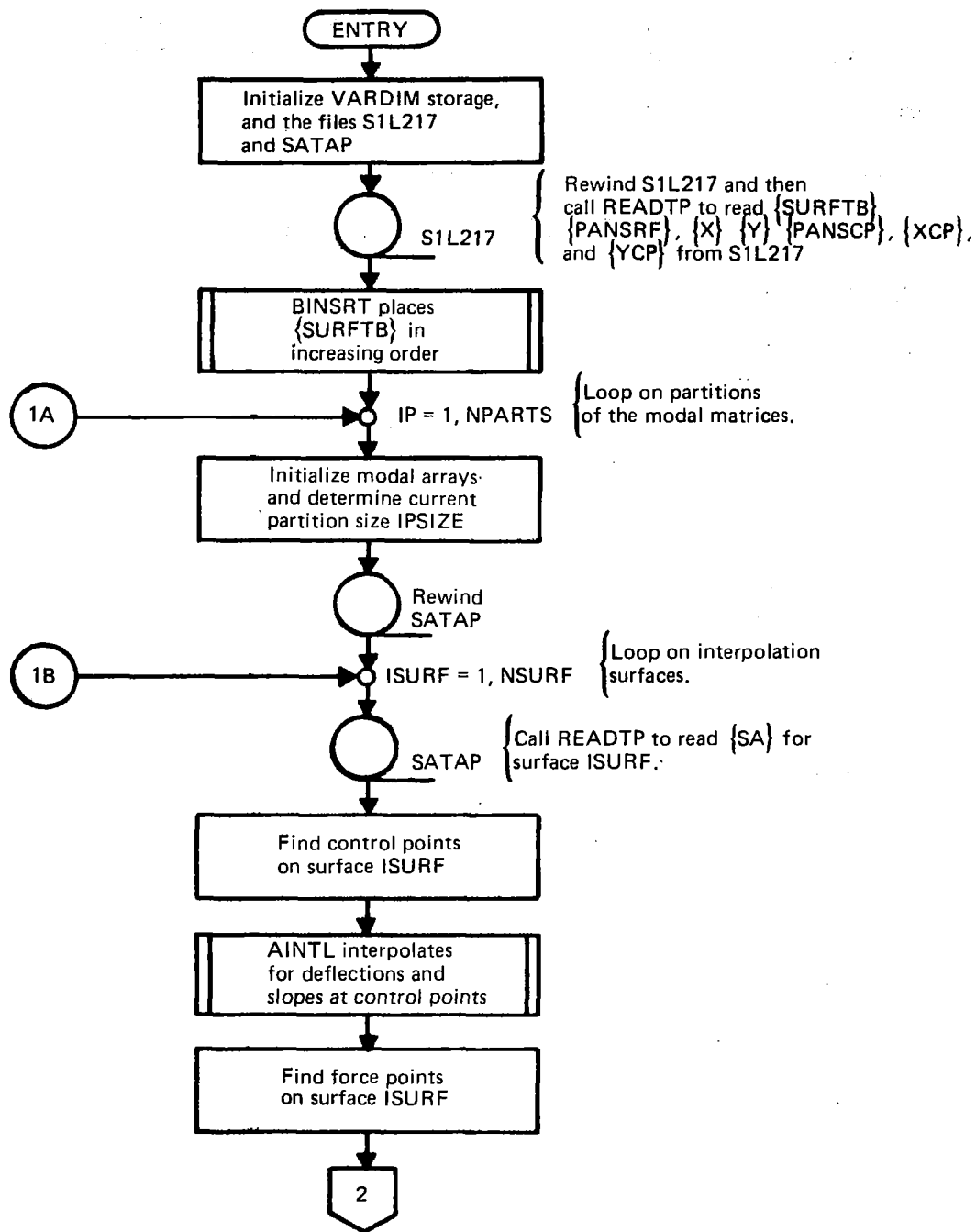


Figure 14. — Macro Flow Chart of Overlay (L217, 3, 3), FLXMOD

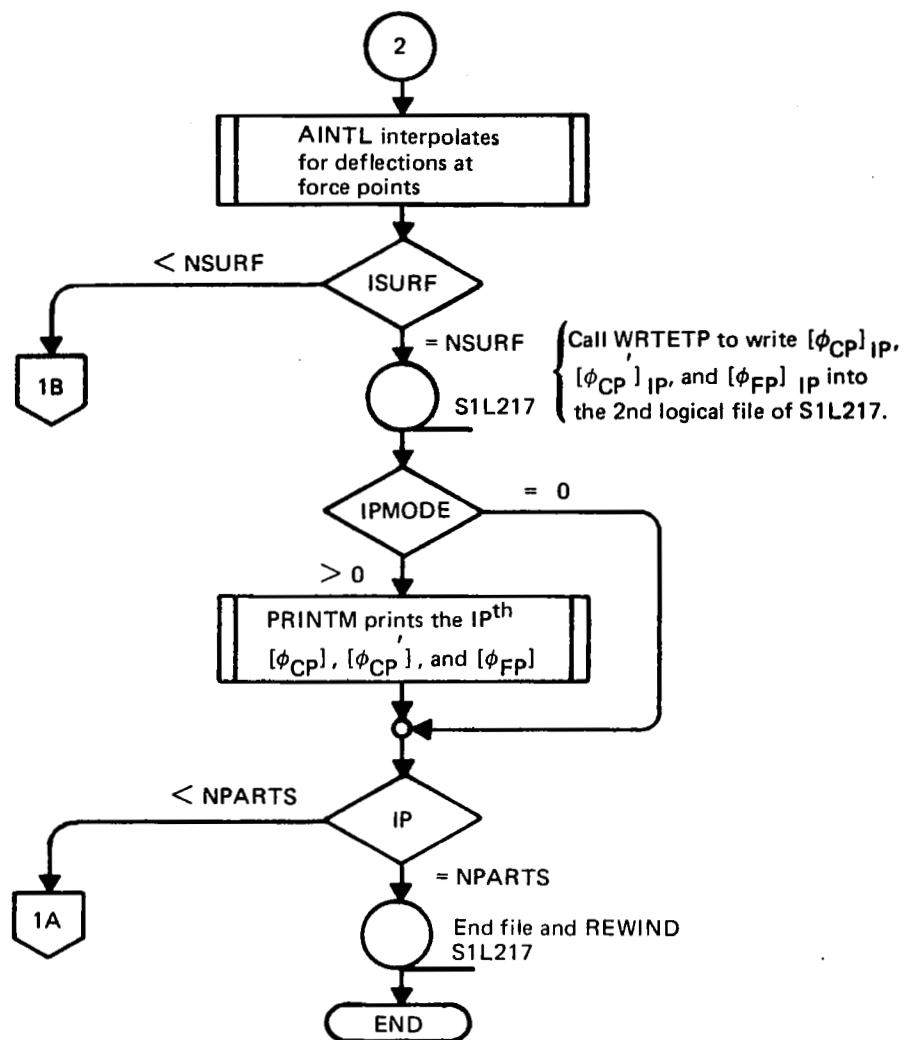


Figure 14. — (Concluded)

*Table 9. — Routines Called by FLXMOD*

OVERLAY (L217,3,3)

PROGRAM FLXMOD

---

AINTL+

BINSRT

FETAD+

FETDEL+

INITIR+

PFINTM+

READTP+

SETMFL

STARTR+

WRTETP+

+ indicates a routine in the DYLOFLEX  
alternate subroutine library.

The macro flow chart of this overlay is shown in figure 15.

The routines called are displayed in table 10.

### I/O Devices of FLXFRC

FLXFRC reads from the files:

S1L217     Matrices  $[\hat{A}]$ ,  $[\Sigma]$ ,  $[\hat{F}AC]$ ,  $[GC]$ ,  $[\hat{R}G]$ ,  $[\phi_{CP}]$ ,  $[\phi'_{CP}]$ , and  $[\phi_{FP}]$   
(See sec. 3.6.3 for a description.)

SDINDEX     Table describing the FLEXSTAB aerodynamic data on SDDATA

SDDATA     Matrix AIC by rows

The AIC matrix read is known inside FLEXSTAB as  $Ap_\theta$ . (See sec. 6.4 of vol. I and ref. 3 for a complete description of both SDINDEX and SDDATA.)

FLXFRC writes onto the file:

S3L217     the matrices

$[F_1]$      (partitioned if necessary)

$[F_2]$      (partitioned if necessary)

$[FG]$      (by columns)

### 3.3.5 OVERLAY(L217,3,5), FLXODR

#### Purpose of FLXODR

FLXODR sorts the aerodynamic force matrices according to the interpolation surface number corresponding with each element. The resulting surface force matrices are written onto the file EOMLOD.

The macro flow chart of this overlay is shown in figure 16.

The routines called are displayed in table 11.

### I/O Devices of FLXODR

FLXODR reads from the files:

S1L217     The matrices

$\{SURFTB\}$

$\{IPNSRF\}$

$\{X\}$

$\{Y\}$

$\{AREA\}$

}     See section 3.6.3

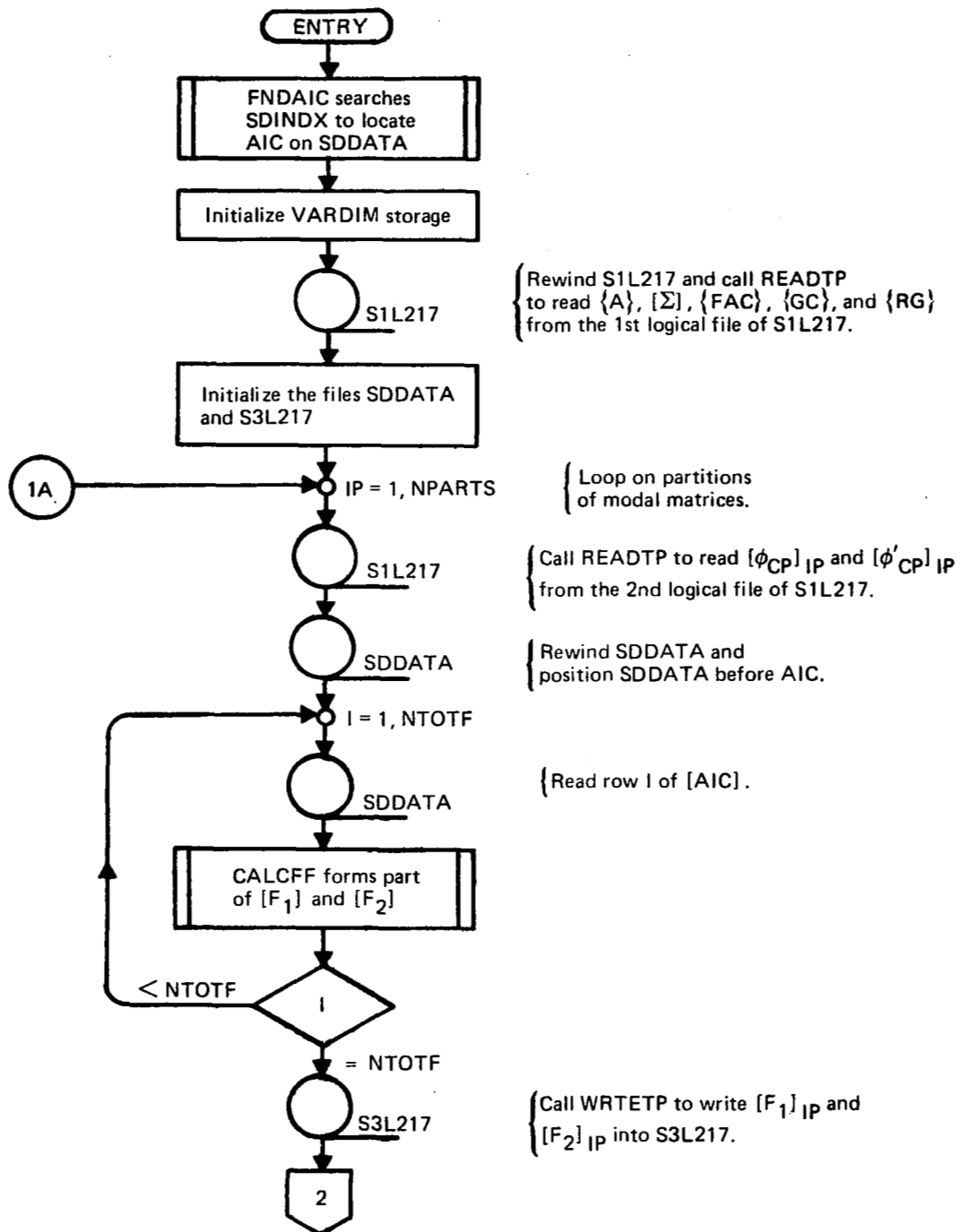


Figure 15. — Macro Flow Chart of Overlay (L217 3, 4), FLXFRC

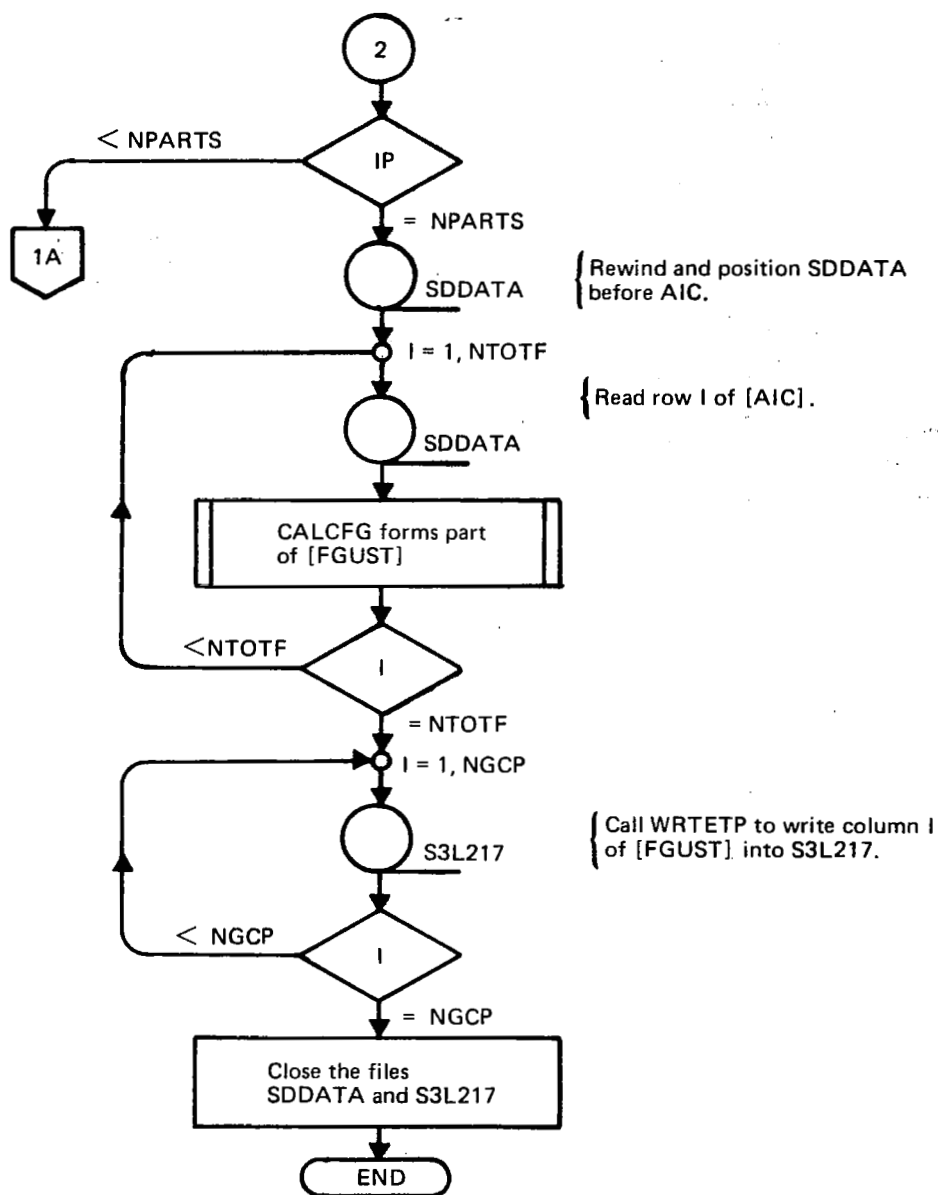


Figure 15. — (Concluded)

*Table 10. — Routines Called by FLXFRC*

OVERLAY (L217, 3, 4)

PROGRAM FLXFRC

---

CALCFF           VIP+

CALCFG

DELETR+

FETAD+

FETDEL+

FNDAIC

FSF+

FSR+

INITIR+

PRINTM+

READTP+

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library.

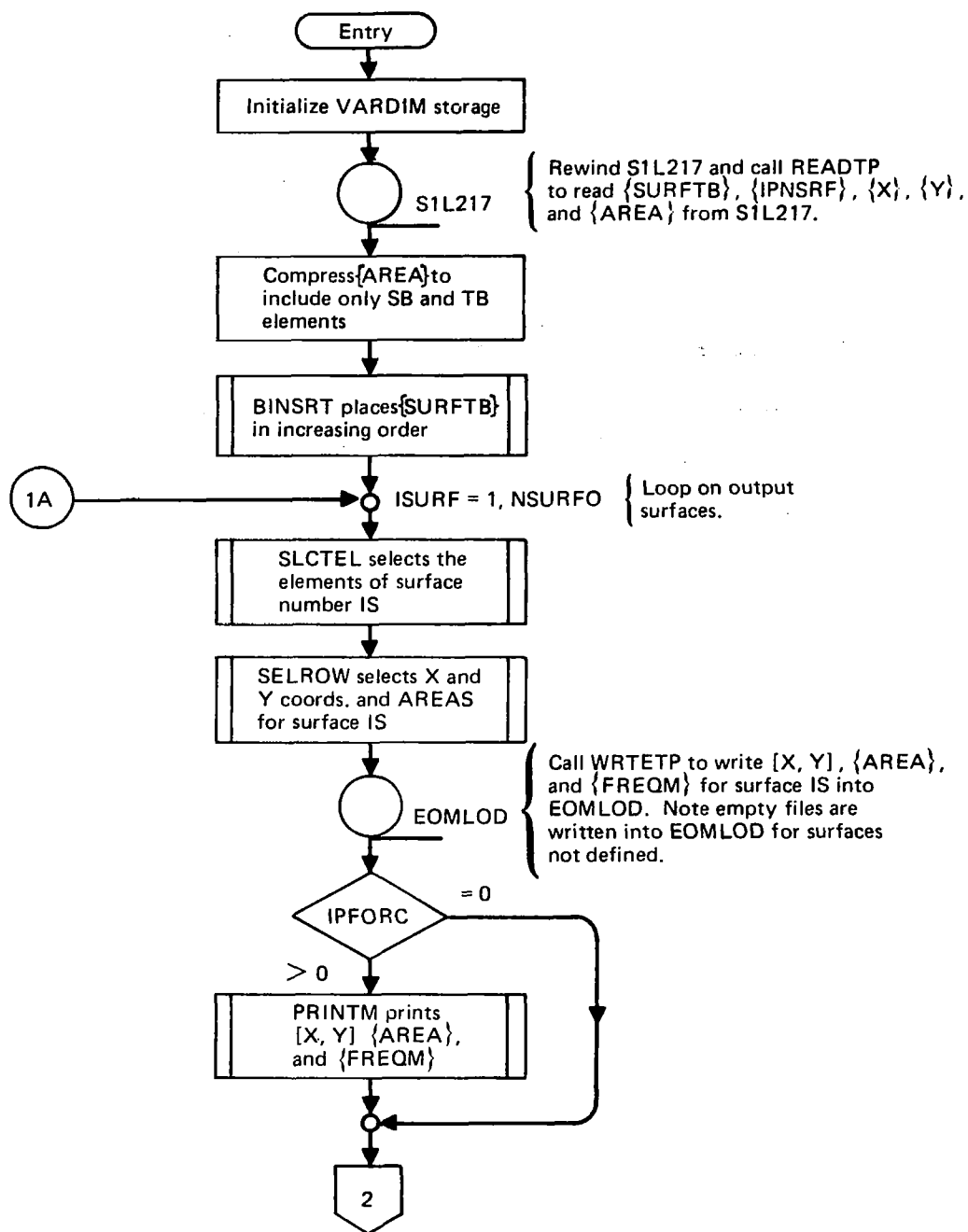


Figure 16. — Macro Flow Chart of Overlay (L217, 3, 5), FLXODR

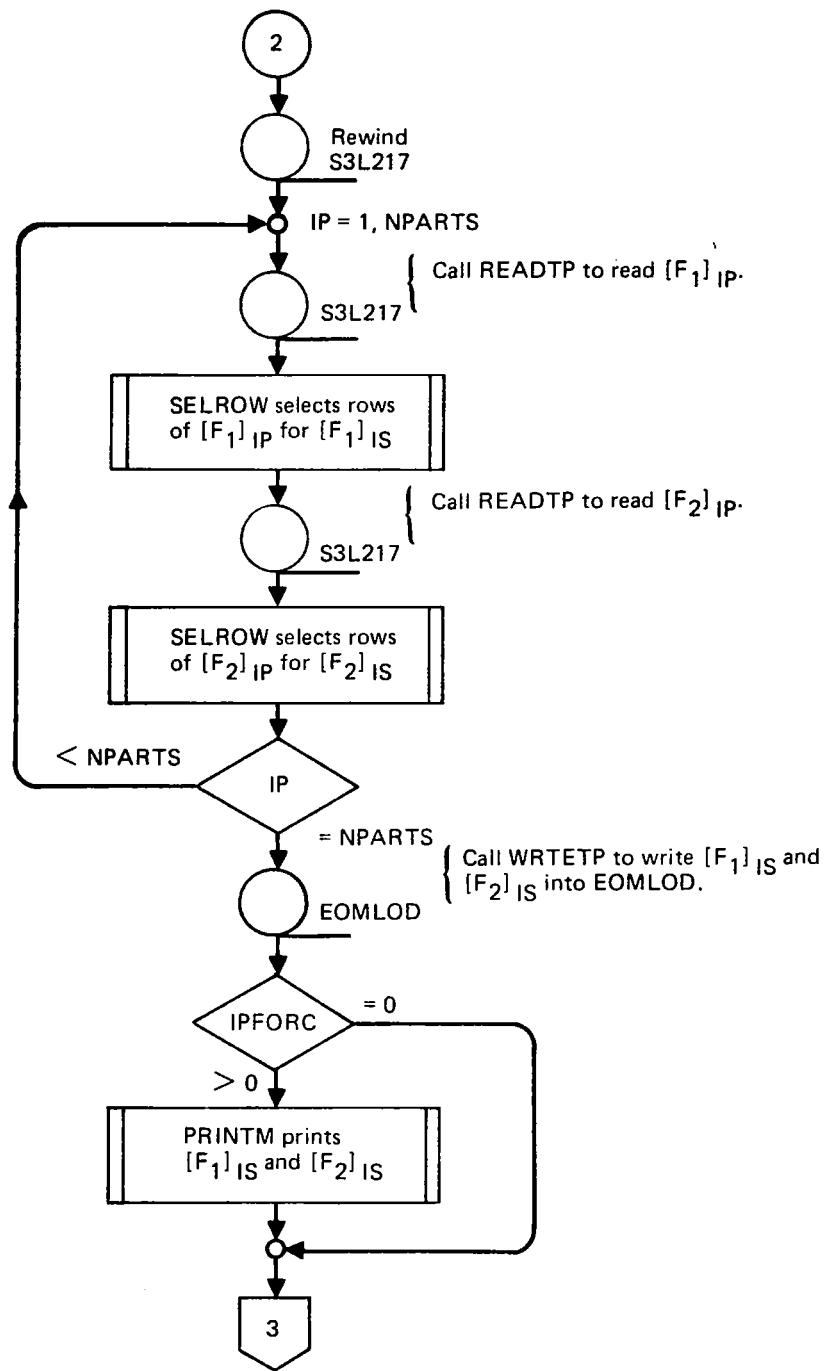


Figure 16. — (Continued)

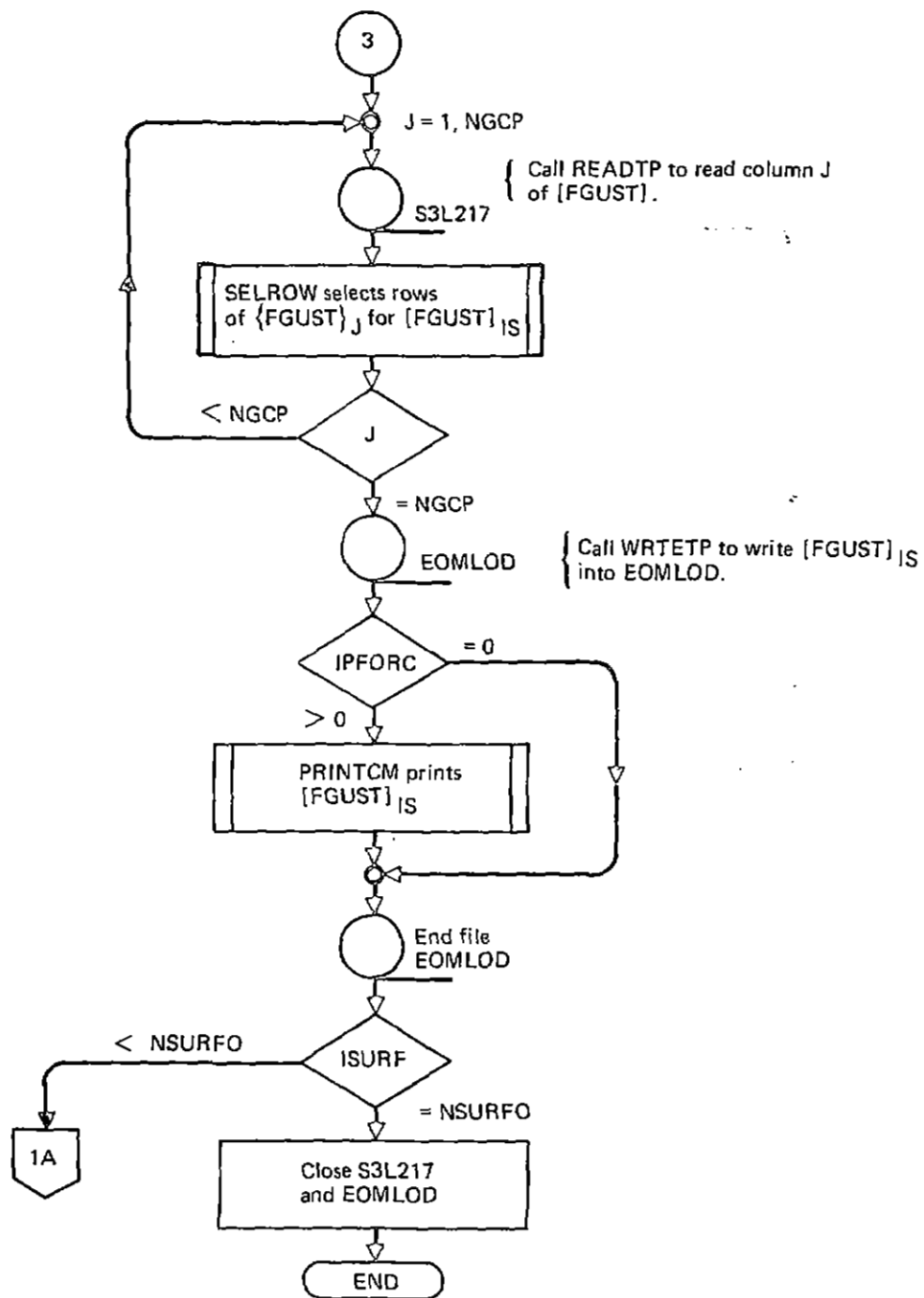


Figure 16. — (Concluded)

Table 11. - Routines Called by FLXODR

OVERLAY (L2 17, 3, 5)

PROGRAM FLXODR

-----

BINSRT

DELETR+

FETAD+

FETDEL+

INITIR+

PFINTM+

PFNTCM+

READTP+

SELROW

SETMFL

SICTEL

STAPTR+

WRTETP+

+ indicates a routine in the DYLOFLEX  
alternate subroutine library

S3L217     The matrices  
            $[F_1]$     (partitioned if necessary)  
            $[F_2]$     (partitioned if necessary)  
            $[FG]$     (by columns)

FLXODR writes onto the file:

EOMLOD    The following matrices for each surface in a separate logical file

$\left. \begin{array}{l} [X,Y] \\ \{AREA\} \\ [F_1] \\ [F_2] \\ [FG] \end{array} \right\}$	See section 6.5.2 of volume I
--	----------------------------------

### 3.3.6 OVERLAY(L217,3,6), FLXEOM

#### Purpose of FLXEOM

FLXEOM generates the file EOMTAP containing the equations of motion matrices  $[M_1]$ ,  $[M_2]$ ,  $[M_3]$ ,  $[M_4]$ ,  $[M_5]$ , and  $[\tilde{\phi}]$ . The structural equations of motion ( $[M_1]$ ,  $[M_2]$ , and  $[M_3]$ ) are copied from S2L217 where they were stored by STRUCT. The aerodynamic equations of motion are formed

$$[M_4] = -[\phi_{FP}]^T [\overset{\circ}{SF}] [F_1]$$

$$[M_5] = -[\phi_{FP}]^T [\overset{\circ}{SF}] [F_2]$$

$$[\tilde{\phi}] = [\phi_{FP}]^T [\overset{\circ}{SF}] [FG]$$

using the  $[F_1]$ ,  $[F_2]$ , and  $[FG]$  stored on S3L217 by FLXFRC.

The macro flow chart of this overlay is shown in figure 17.

The routines called are displayed in table 12.

#### I/O Devices of FLXEOM

FLXEOM reads from the files:

S1L217	The matrices $[\overset{\circ}{SF}]$ $[\phi_{FP}]$	from the first logical file from the second logical file
S2L217	The matrices $[M_1]$ $[M_2]$ $[M_3]$	(optional)

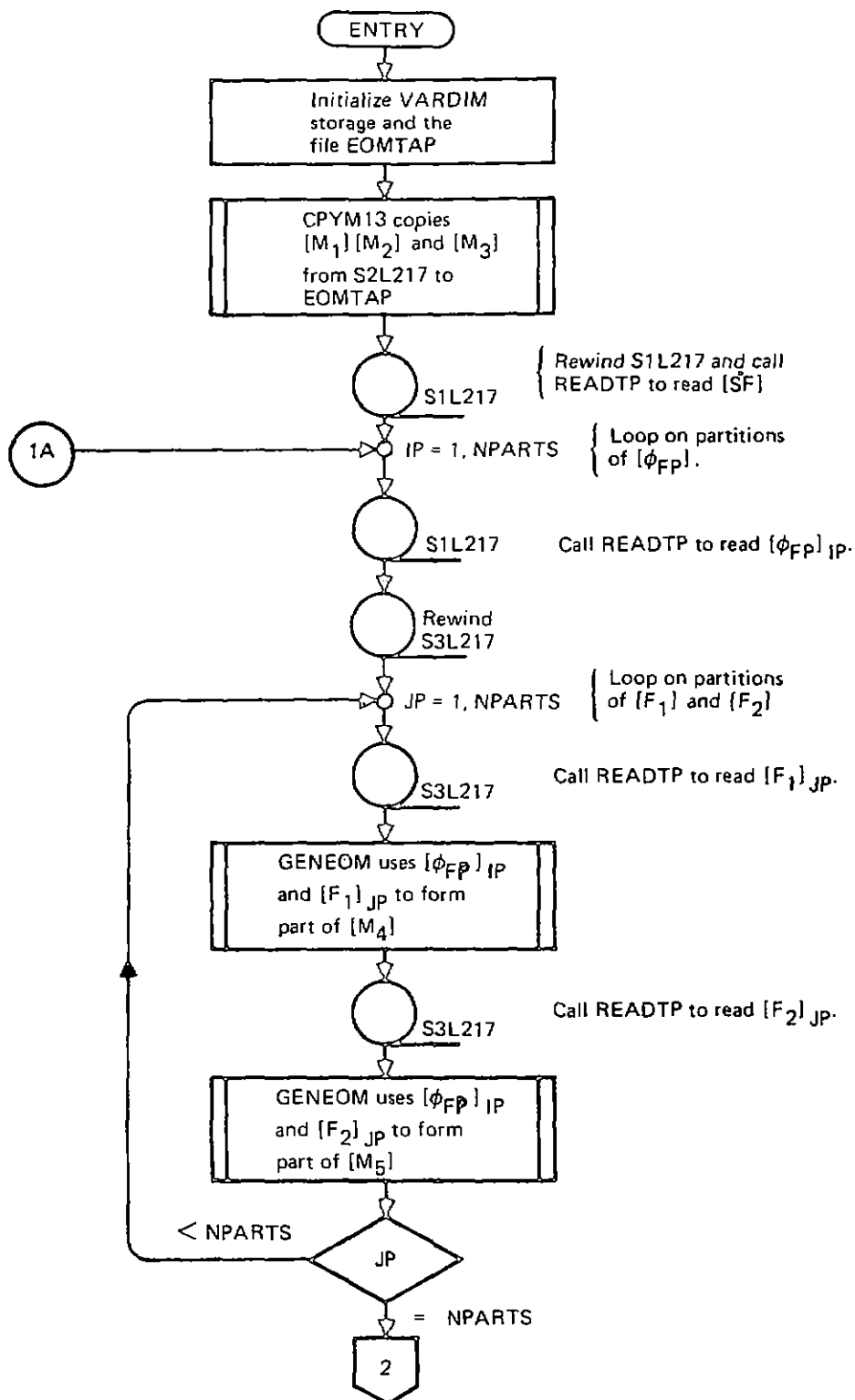


Figure 17. — Macro Flow Chart of Overlay (L217, 3, 6), FLXEOM

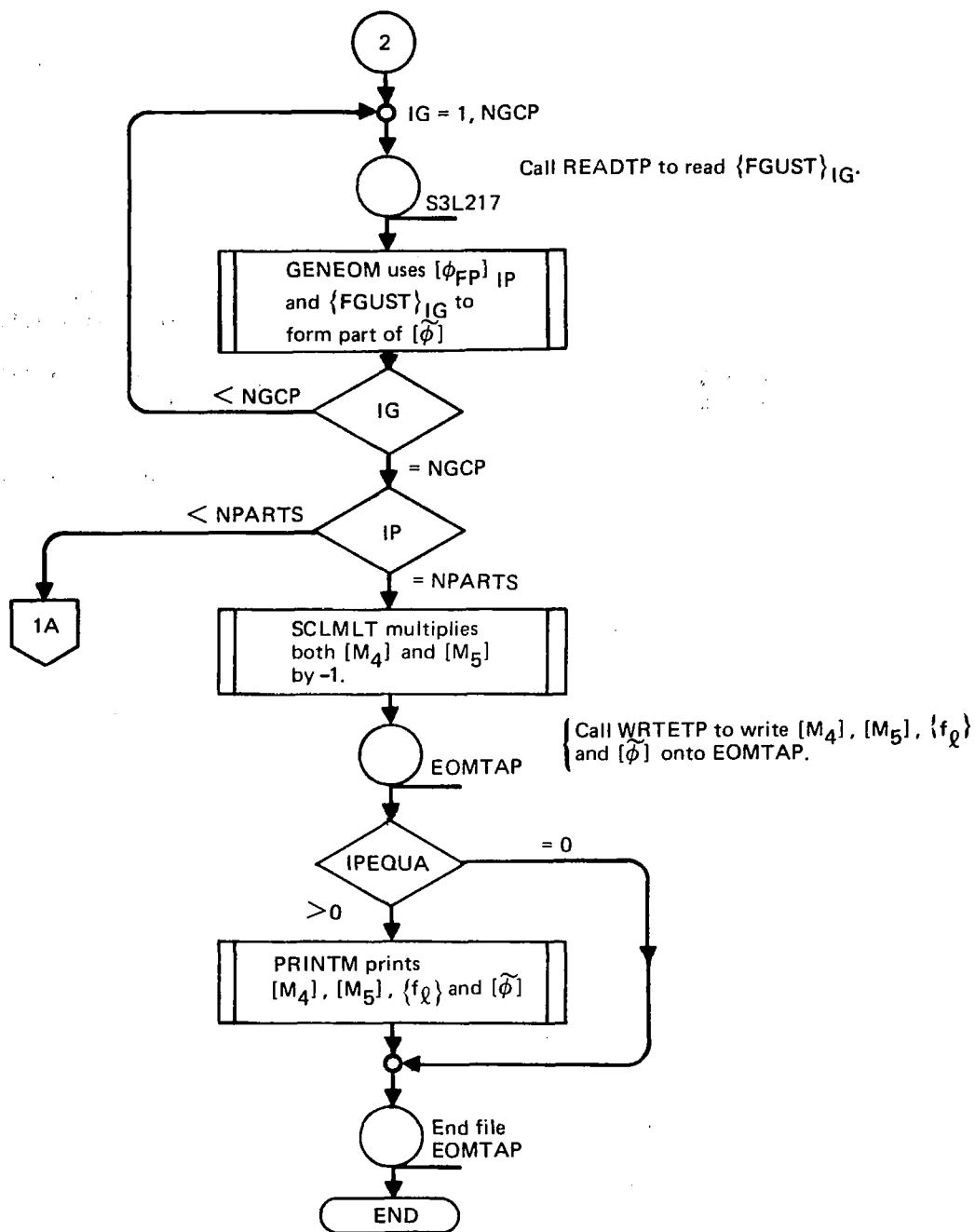


Figure 17. -- (Concluded)

Table 12. — Routines Called by FLXEOM

OVERLAY (L217, 3, 6)

PROGRAM FLXEOM

---

CPYM13	{	FETAD+
		FETDEL+
		PRINTM+
		READTP+
		WRTETP+

DELETR+

FETAD+

FETDEL+

GENEOM      VIP+

INITIR+

PRINTM+

PRNTCM+

READTP+

SCLMLT

SETMFL

STARTR+

WRTETP+

+ indicates a routine in the DYLOFLEX  
alternate subroutine library

**S3L217      The matrices**

$[F_1]$	(partitioned if necessary)
$[F_2]$	(partitioned if necessary)
$[FG]$	(by columns)

See section 3.6.3 for a detailed description of S1L217, S2L217, and S3L217.

**FLXEOM** writes the following matrices onto the file EOMTAP:

$\{ \text{HEADER} \}$	}      (optional) See section 6.5.2 of volume I
$[M_1]$	
$[M_2]$	
$[M_3]$	
$\{ \text{FREQM} \}$	
$[M_4]$	
$[M_5]$	
$\{ f_l \}$	
$[ \tilde{\phi} ]$	

### **3.4 OVERLAY(L217,4,0), DLAIC**

#### **Purpose of DLAIC**

**DLAIC** generates aerodynamic force matrices and equations of motion coefficient matrices based upon the L216 (DUBFLX)(ref. 4) Doublet Lattice AIC matrices.

#### **Analytical Steps of DLAIC**

**DLAIC** performs its task in the following steps:

1. Print the message NOW IN DLAIC TO..., initialize the count of errors, and initialize the scratch file named S1L217.
2. Call overlay (L217,4,1), DLACDS, to read card set 3.0.
3. Call overlay (L217,4,2), DLAGEO, to read the Doublet Lattice geometry data from NGETP, combine it with card input data from DLACDS, and prepare geometry arrays needed in steps 4 through 10.
4. Call overlay (L217,4,3), DLAMOD, to interpolate for mode shapes at force and control points.

Repeat steps 5 through 8 for each frequency at which the aerodynamics are defined.

5. Call overlay (L217,4,4), CPANDW, to generate the arrays  $[CP_{SB}]$ ,  $[CPG_{SB}]$ ,  $[W_{TB}]$ , and  $[WG_{TB}]$ .
6. Call overlay (L217,4,5), FORMWS, to generate the arrays  $[W]$  and  $[WG]$ .
7. Call overlay (L217,4,6), SOLVDW, to solve the equation for  $[\Delta_{cp}]$ ,  $[D][\Delta_{cp}] = [W/WG]$ .
8. Call overlay (L217,4,7), DLAFCR, to generate the arrays  $[FR]$  and  $[FG]$ .
9. Call overlay (L217,4,10g), DLAODR, to sort the aerodynamic forces per surface and write them onto the file EOMLOD.
10. Call overlay (L217,4,11g), DLAEOM, to prepare  $[M_4]$ ,  $[M_5]$ , and  $[\tilde{\phi}]$  and generate the file EOMTAP.
11. Return to the calling program.

The macro flow chart of this overlay is shown in figure 18.

The routines called are displayed in table 13.

The equations solved by DLAIC are summarized as follows:

$$[FR] = [F\ddot{A}C] \begin{bmatrix} [0] \\ \text{-----} + q[\ddot{\Sigma}^*][A_{TB/IB}][D]^{-1}[W_{AUG}] \\ q[\ddot{A}_{SB}][CP_{SB}] \end{bmatrix}$$

$$\text{where: } [W_{AUG}] = - \begin{bmatrix} [\phi'_{CP}]_{TB} & i\omega[\phi_{CP}]_{TB} \\ \text{-----} & \text{-----} \\ [0] & [0] \end{bmatrix} + [F][CP_{SB}]$$

$$\text{and: } [CP_{SB}] = 2\pi \left[ \ddot{R}' + \frac{i\omega}{2v} \ddot{R} \right] \left[ [\phi'_{CP}]_{SB} + \frac{i\omega}{v} [\phi_{CP}]_{SB} \right] + \pi \ddot{R} \left[ [\phi''_{CP}]_{SB} + \frac{i\omega}{v} [\phi'_{CP}]_{SB} \right]$$

$$[FG] = [F\ddot{A}C] \begin{bmatrix} [0] \\ \text{-----} + q[\ddot{\Sigma}^*][\ddot{A}_{TB/IB}][D]^{-1}[WG_{AUG}] \\ q[\ddot{A}_{SB}][CPG_{SB}] \end{bmatrix}$$

$$\text{where: } [WG_{AUG}] = \frac{1}{v} \begin{bmatrix} [\ddot{R}G]_{TB} \\ [0] \end{bmatrix} \begin{bmatrix} [GC]_{TB} \\ [0] \end{bmatrix} + [F][CPG_{SB}]$$

$$\text{and: } [CPG_{SB}] = -\frac{2\pi}{v} \begin{bmatrix} \ddot{R}' & [\ddot{G}C^*_{SB}] \end{bmatrix}$$

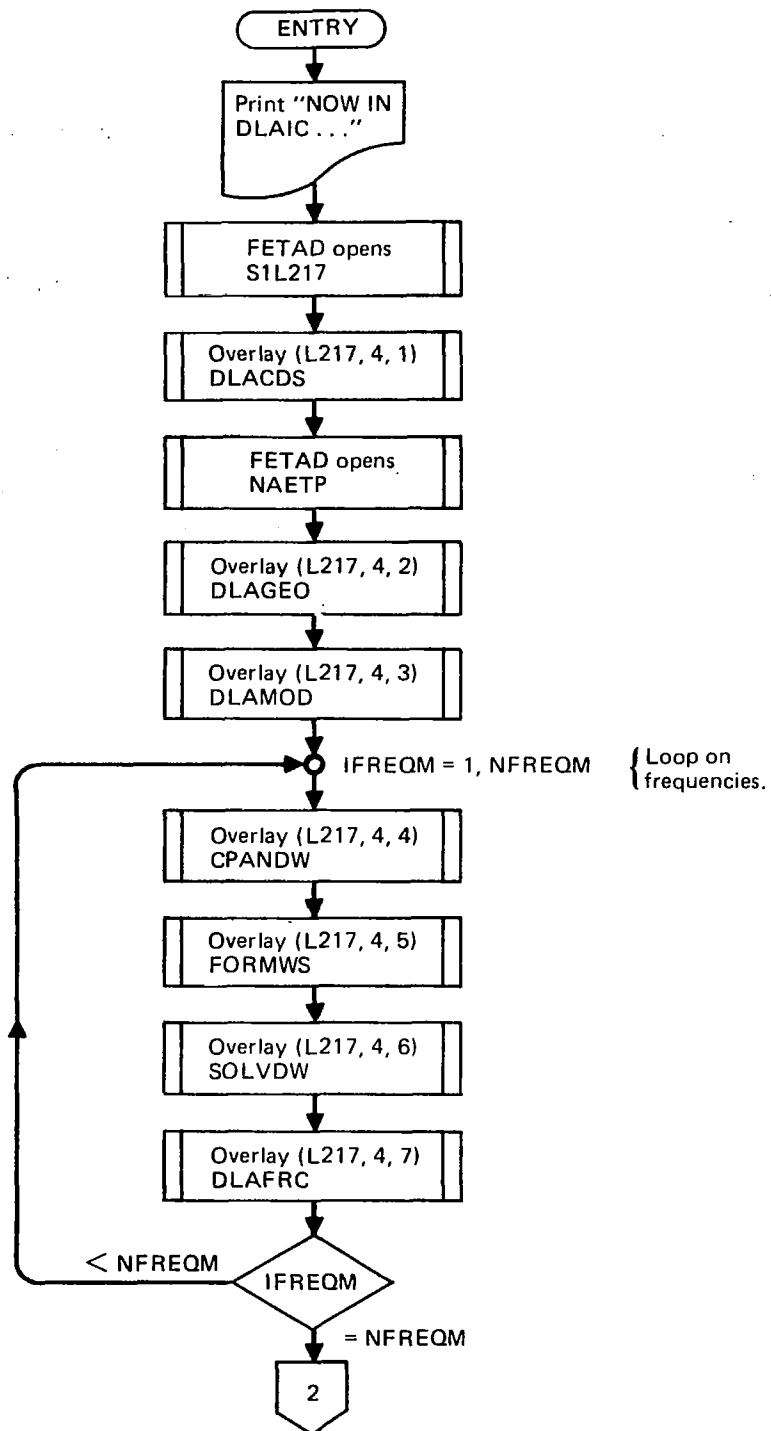


Figure 18. — Macro Flow Chart of Overlay (L217, 4, 0), DLAIC

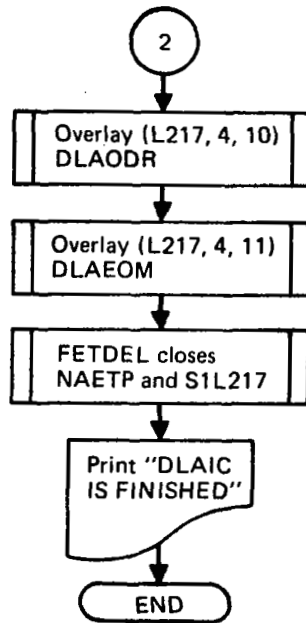


Figure 18. — (Concluded)

Table 13. — Routines Called by DLAIC

OVERLAY (L217, 4, 0)

PFOGFAM DLAIC

---

CPANDW	-	OVERLAY (L217, 4, 4)
DLACDS	-	OVERLAY (L217, 4, 1)
DLAEOM	-	OVERLAY (L217, 4, 11)
DLAFRC	-	OVERLAY (L217, 4, 7)
DLAGEO	-	OVERLAY (L217, 4, 2)
DLAMOD	-	OVERLAY (L217, 4, 3)
DLAODR	-	OVERLAY (L217, 4, 10)
FORMWS	-	OVERLAY (L217, 4, 5)
SOLVDW	-	OVERLAY (L217, 4, 6)
FETAD+		
FETDEL+		

+ indicates routines from the DYLOFLEX  
alternate subroutine library

$$[F_1] = [FR]_{\text{Real}}$$

$$[F_2] = [FR]_{\text{Imaginary}}$$

$$[QR] = [\phi_{FP}]_{TB/SB}^T [\overset{\circ}{SF}] [FR]$$

$$[M_4] = -[QR]_{\text{Real}}$$

$$[M_5] = -\frac{1}{\omega} [QR]_{\text{Imaginary}}$$

$$[\tilde{\phi}] = [\phi_{FP}]_{TB/SB}^T [\overset{\circ}{SF}] [FG]$$

Note: For a quasi-steady solution, the two expressions of  $\frac{i\omega}{\gamma}$  in  $[CP_{SB}]$  become simply  $\frac{i}{\gamma}$ .

### I/O Devices of DLAIC

DLAIC prints two messages on the output file; NOW IN DLAIC..., and DLAIC IS FINISHED... All other file communication in DLAIC is performed by its secondary overlays. Figure 18 shows the files providing input and output to DLAIC's overlays.

In subsections 3.4.2 through 3.4.9 the matrices read from and written onto each file are listed. (See secs. 6.4 through 6.5 of vol. I, *Engineering and Usage*, for detailed descriptions of the format and content of the files for external communication.) Section 3.6.3 of this volume contains the same information for L217 (EOM)'s temporary scratch files.

#### 3.4.1 OVERLAY(L217,4,1), DLACDS

##### Purpose of DLACDS

DLACDS reads card input data directing the processing of Doublet Lattice (L216) AIC matrices. (See card set 3.0 in vol. I of this document, *Engineering and Usage*.) Options, constants, and file names are stored in labelled common blocks for later use. The card data defining the correspondence between Doublet Lattice bodies (thin bodies and slender bodies) and the L215 (INTERP) modal interpolation surfaces are stored in the arrays {IBDTAB} and {ICSTAB} and written onto the temporary storage file S1L217.

The macro flow chart of this overlay is shown in figure 19.

The routines called are displayed in table 14.

##### I/O Devices of DLACDS

DLACDS reads card set 3 from the input file and prints the card images on the output file with descriptive comments and any necessary diagnostics.

DLACDS writes on the file:

S1L217      The arrays {IBDTAB} and {ICSTAB} (see sec. 3.6.3 for contents)

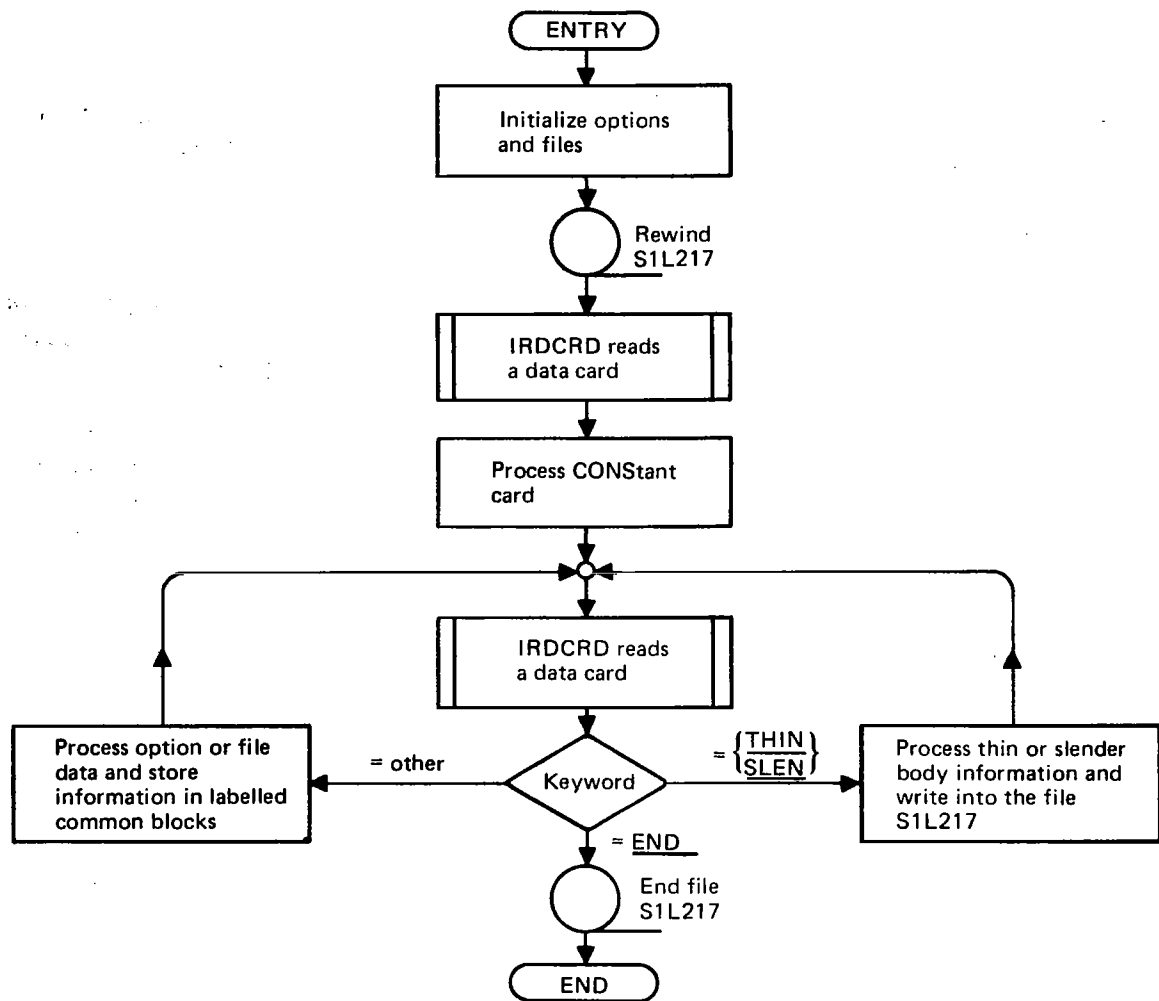


Figure 19. — Macro Flow Chart of Overlay (L217, 4, 1), DLACDS

*Table 14. — Routines Called by DLACDS*

OVERLAY (L2 17, 4, 1)

PROGRAM DLACDS

---

FNDKEY+

IRDCRD+

IFQL+

NAMFIL+

WRTETP+

+ indicates a routine from the DYLOFLEX alternate subroutine library

### 3.4.2 OVERLAY(L217,4,2), DLAGEO

#### Purpose of DLAGEO

DLAGEO reads the Doublet Lattice (L216) geometry data from the file NGETP, combines it with the card input data read from S1L217, and prepares geometry arrays governing the calculation of aerodynamic forces. The arrays prepared are written onto the first logical file of S1L217 (see sec. 3.6.3).

#### Analytical Steps of DLAGEO

DLAGEO performs its tasks in the following steps:

1. Initialize geometry arrays and counters.
2. Call RDLGEO to read the Doublet Lattice (L217) geometry data from the file NGETP.

Rewind S1L217, then repeat steps 3 through 5 for each body (thin or slender) defined via card input to DLACDS; IBOD = 1, NBOD.

3. Read from S1L217 the array {IBDTAB}<sub>IBOD</sub>, the card input data associated with the body. If control surfaces are attached to the body, the array {ICSTAB} is read from S1L217 to define the aerodynamic elements on each of the control surfaces.
4. Add to the array {ISURF} and build the IBOD portion of the array {IPNSRF}.  
    {ISURF}      A table of modal interpolation surfaces  
    {IPNSRF}    A table providing a correspondence between aerodynamic elements and modal interpolation surfaces
5. Build the IBOD portion of the arrays:  
    [FAC]      Used to double the force of slender body elements on the plane of symmetry  
    [SF]      Used to double the force on elements off the plane of symmetry  
    {IGUSTZ}    Indicates the gust zone in which each aerodynamic element falls  
    [RG]      The gust rotation matrix
6. Build the array [SIGMA] to define the correspondence between interference body elements and slender body segments. The [SIGMA] is used to add the interference body forces to the slender body segments.
7. Call PRTGFP and PRTGCP to print Doublet Lattice (L216) force point and control point geometry.
8. Transform the reference axis coordinates of all bodies to local structural coordinates using the subroutine GTOLT.

9. Compress the geometry arrays from NTOTF to NAFP elements by eliminating all interference body element entries.

NTOTF        = Total number of force points

NAFP        = Number of aerodynamics force points on all slender and thin bodies

10. Call WRTGEO to write geometry arrays onto the file S1L217 (see sec. 3.6.3).
11. Read the aerodynamic control matrix from NAETP and extract the reduced frequencies.
12. Return to the calling program.

The macro flow chart of this overlay is shown in figure 20.

The routines called are displayed in table 15.

#### **I/O Devices of DLAGEO**

DLAGEO reads from the files:

NGETP        Doublet Lattice (L216) geometry arrays (see sec. 6.4.4 of vol. I)

NAETP        Doublet Lattice (L216) aerodynamic control matrix (see sec. 6.4.5 of vol. I)

S1L217        Arrays {IBDTAB} and {ICSTAB}

DLAGEO writes onto the files:

OUTPUT       Geometry tables for force and control points

S1L217        All geometry arrays required by subsequent DLAIC secondary overlays (see sec. 3.6.3)

#### **3.4.3 OVERLAY(L217,4,3), DLAMOD**

##### **Purpose of DLAMOD**

DLAMOD interpolates over the mode shapes defined in an SA array from L217 (INTERP) to find:

$[\phi_{FP}]$         Modal deflections at force points

$[\phi_{CP}]$         Modal deflections at control points

$[\phi'_{CP}]$         Modal slopes at control points

$[\phi''_{CP}]$         Second derivatives of modes at the control points

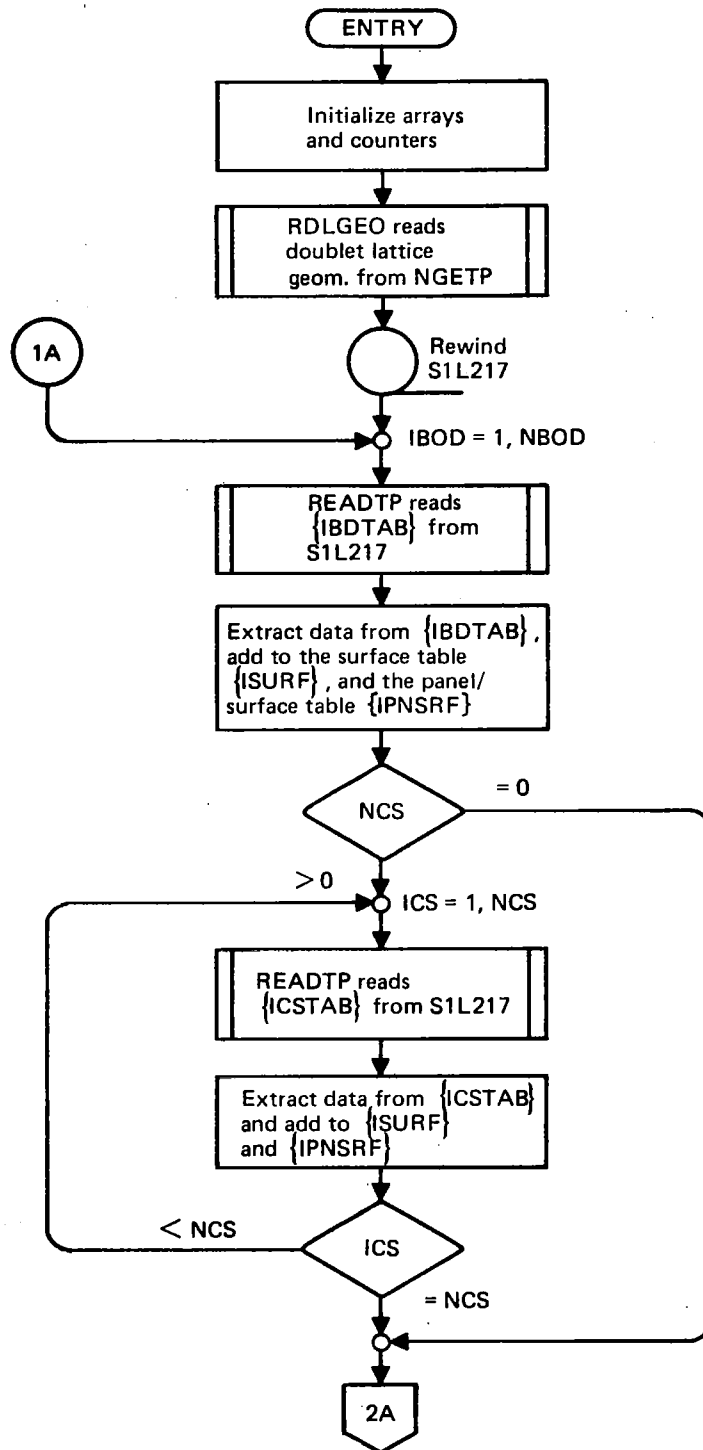


Figure 20. — Macro Flow Chart of Overlay (L217, 4, 2), DLAGEO

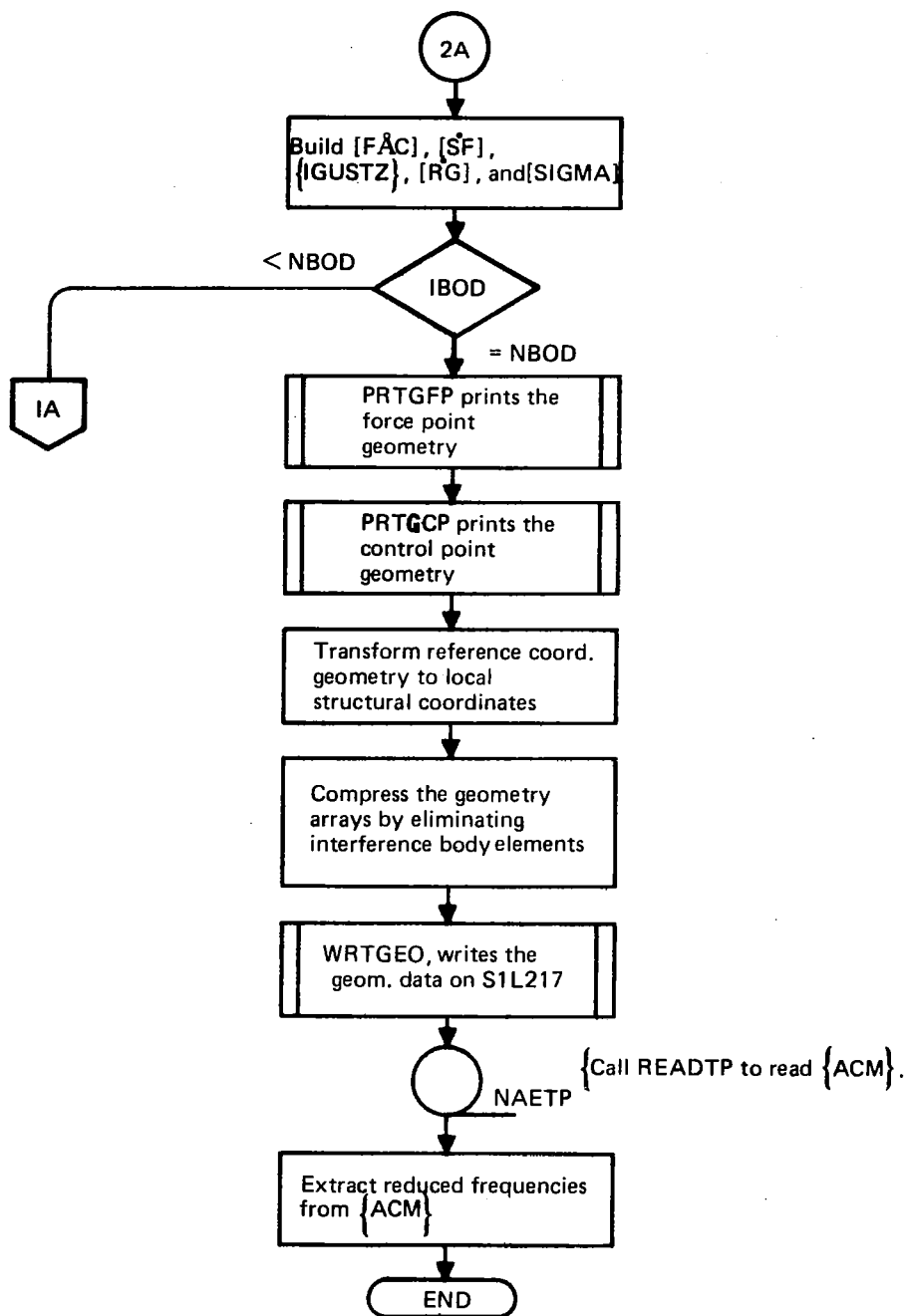


Figure 20. — (Concluded)

Table 15. — Routines Called by DLAGEO

OVERLAY (L2 17, 4, 2)

PROGRAM DLAGEO

---

GTOLT+

IRQL+

PFTGCP

PRTGFP

RDLGEO

FETAD+

FETDEL+

READTP+

WRTGEO

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

## Analytical Steps of DLAMOD

DLAMOD calls AINTL, a DYLOFLEX library routine, to perform the interpolation. If more than 20 modes are defined, the arrays are generated and written onto the temporary file S1L217 in partitions with up to 20 modes per partition. See section 3.6.3 for the format of S1L217.

The macro flow chart of this overlay is shown in figure 21.

The routines called are displayed in table 16.

## I/O Devices of DLAMOD

DLAMOD reads from the files:

SATAP        {SA} arrays defining modal data

S1L217        Geometry arrays

$\left. \begin{array}{l} \{SURFTB\} \\ \{IPNSRF\} \\ \{X\} \\ \{Y\} \\ \{IPNSCP\} \\ \{XCP\} \\ \{YCP\} \end{array} \right\}$	See section 3.6.3
---	-------------------

DLAMOD writes onto the file:

S1L217        Interpolated modal data (see sec. 3.6.3)

### 3.4.4 OVERLAY(L217,4,4), CPANDW

#### Purpose of CPANDW

For a particular frequency CPANDW forms the arrays:

$$[CP_{SB}] = -2\pi \left[ [\dot{R}'] + \frac{i\omega}{2v} [\dot{R}] \right] \left[ [\phi'_{CP}]_{SB} + \frac{i\omega}{v} [\phi_{CP}]_{SB} \right] - \pi [\dot{R}] \left[ [\phi''_{CP}]_{SB} + \frac{i\omega}{v} [\phi'_{CP}]_{SB} \right]$$

For a quasi-steady solution, the factors multiplying the imaginary parts change to 0.0, 1/v, and 1/v, respectively.

$$\begin{aligned} [CPG_{SB}] &= -\frac{2\pi}{v} [\dot{R}] [\dot{R}G]_{SB} [GC^*]_{SB} \\ [W_{TB}] &= -\left[ [\phi'_{CP}]_{TB} + \frac{i\omega}{v} [\phi_{CP}]_{TB} \right] \\ [WG_{TB}] &= \frac{1}{v} [\dot{R}G]_{TB} [GC^*]_{TB} \end{aligned}$$

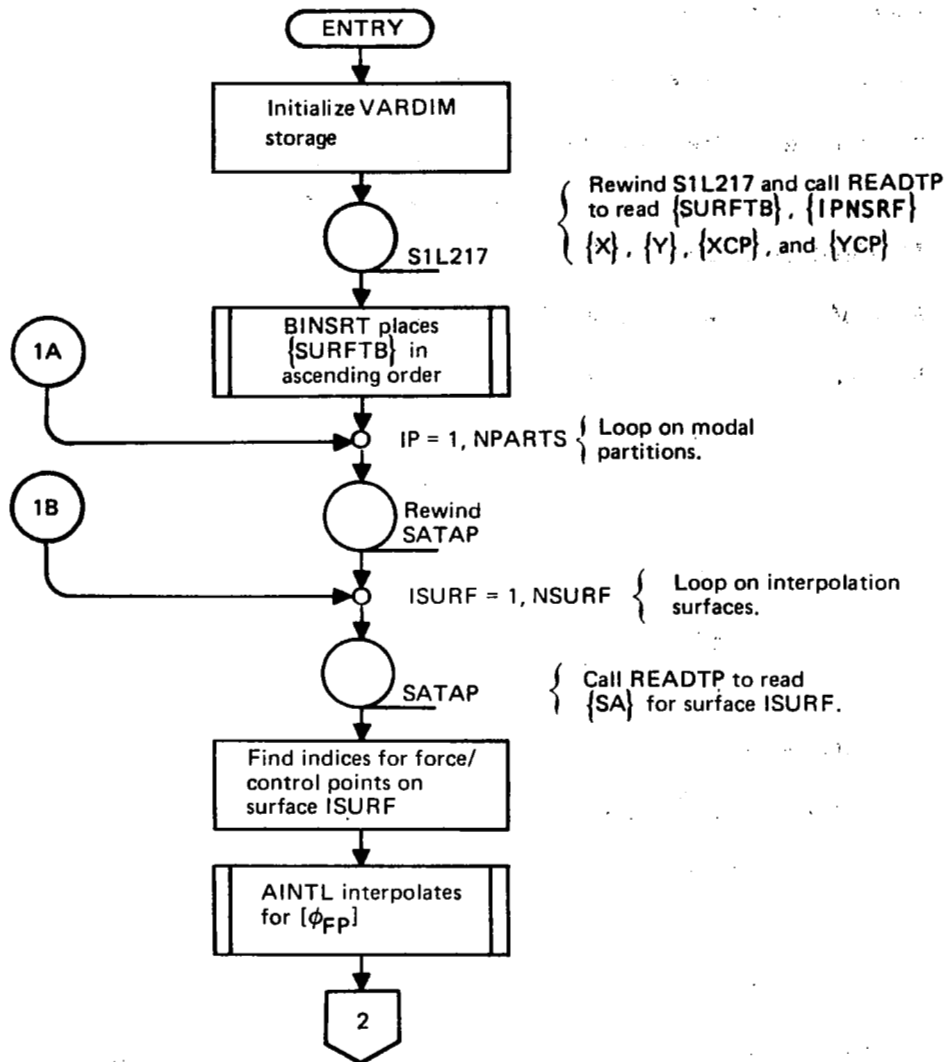


Figure 21. — Macro Flow Chart of Overlay (L217, 4, 3), DLAMOD

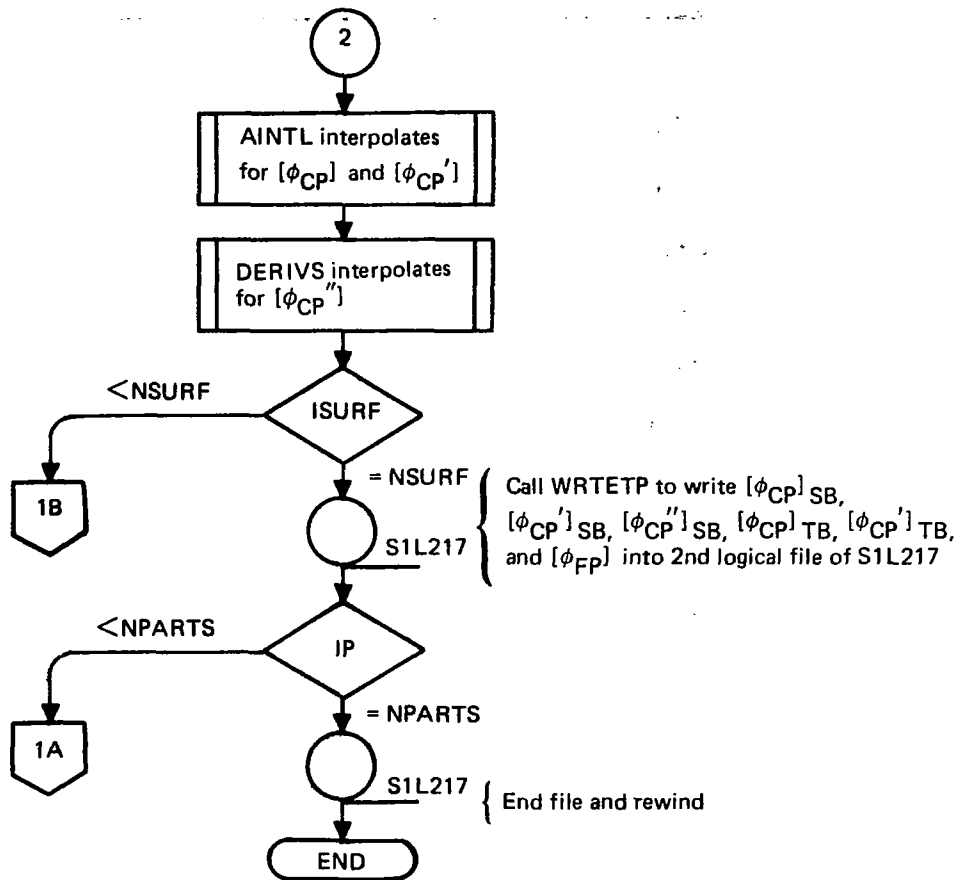


Figure 21. --(Concluded)

*Table 16. — Routines Called by DLAMOD*

OVERLAY (L217, 4, 3)

PROGRAM DLAMOD

---

AINTL+

BINSRT

DERIVS

FETAD+

FETDEL+

INITIR+

PRINTM+

READTP+

SETMFL

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

The macro flow chart of this overlay is shown in figure 22.

The routines called are displayed in table 17.

### I/O Devices of CPANDW

CPANDW reads from the file:

S1L217      Geometry arrays

$$\left. \begin{array}{l} [\dot{G}C] \\ [\dot{R}G] \\ [\dot{R}] \\ [\dot{R}'] \end{array} \right\} \text{ See section 3.6.3}$$

and the modal data arrays

$$\left. \begin{array}{l} [\phi_{CP}]_{SB}, [\phi'_{CP}]_{SB}, [\phi''_{CP}]_{SB}, \\ [\phi_{CP}]_{TB}, \text{ and } [\phi'_{CP}]_{TB} \end{array} \right\} \text{ See section 3.6.3}$$

CPANDW writes onto the file:

S1L217      The arrays

$$\left. \begin{array}{l} [CP_{SB}] \\ [CPG_{SB}] \\ [W_{TB}] \\ [WG_{TB}] \end{array} \right\} \text{ See section 3.6.3}$$

### 3.4.5 OVERLAY(L217,4,5), FORMWS

#### Purpose for FORMWS

FORMWS forms the matrices:

$$[W] = \frac{[W_{TB}]}{[0]} + [F][CP_{SB}]$$

$$[WG] = \frac{[WG_{TB}]}{[0]} + [F][CPG_{SB}]$$

and writes them onto the file NTP4 to be used as the right hand sides of the  $\Delta C_p$  solution in SOLVDW.

The macro flow chart of this overlay is shown in figure 23.

The routines called are displayed in table 18.

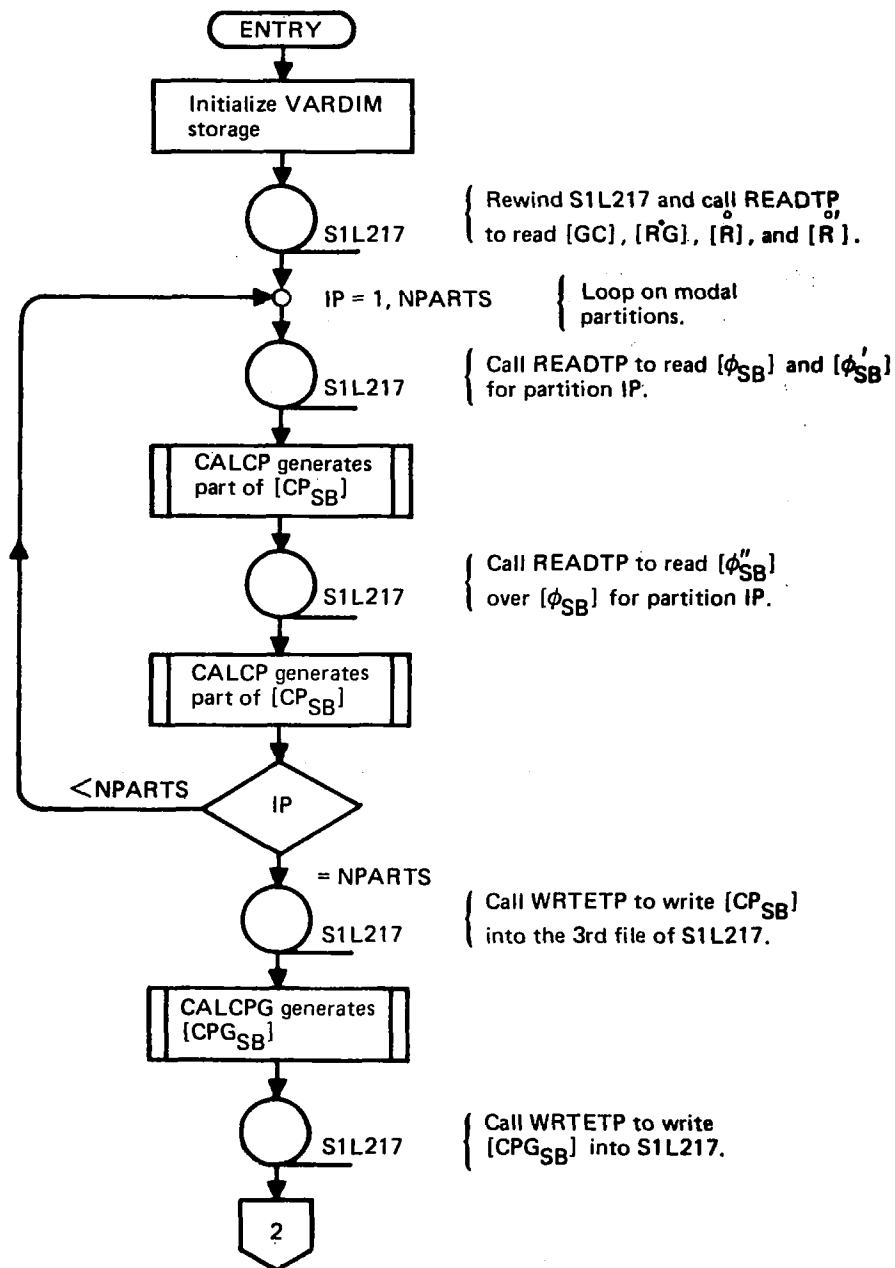


Figure 22. — Macro Flow Chart of Overlay (L217, 4, 4), CPANDW

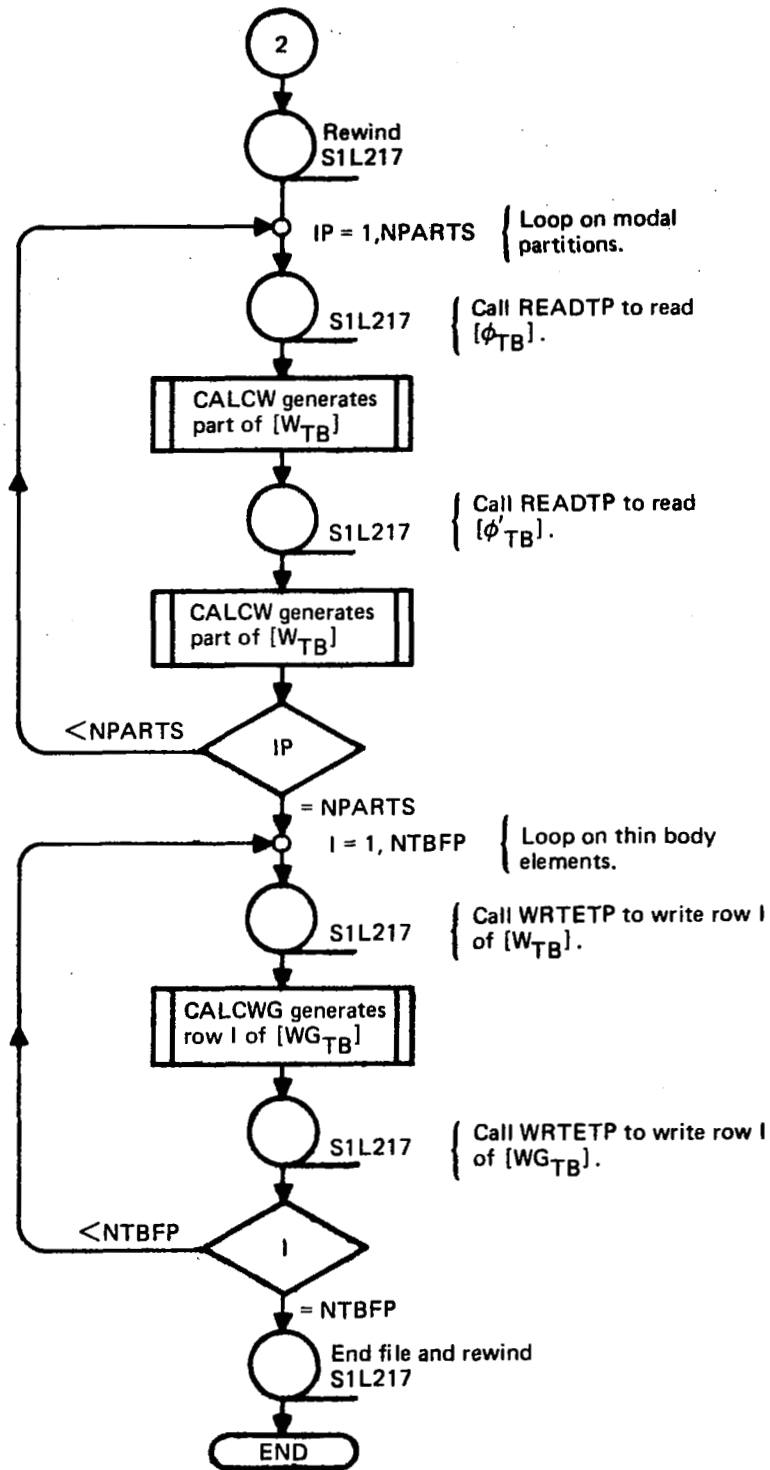


Figure 22. — (Concluded)

*Table 17. — Routines Called by CPANDW*

OVERLAY (L217, 4, 4)

PROGRAM CPANDW

---

CALCP

CALCPG

CALCW

CALCWG

DELETR+

INITIR+

PRINTM+

PRNTCM+

READTP+

SETMFL

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

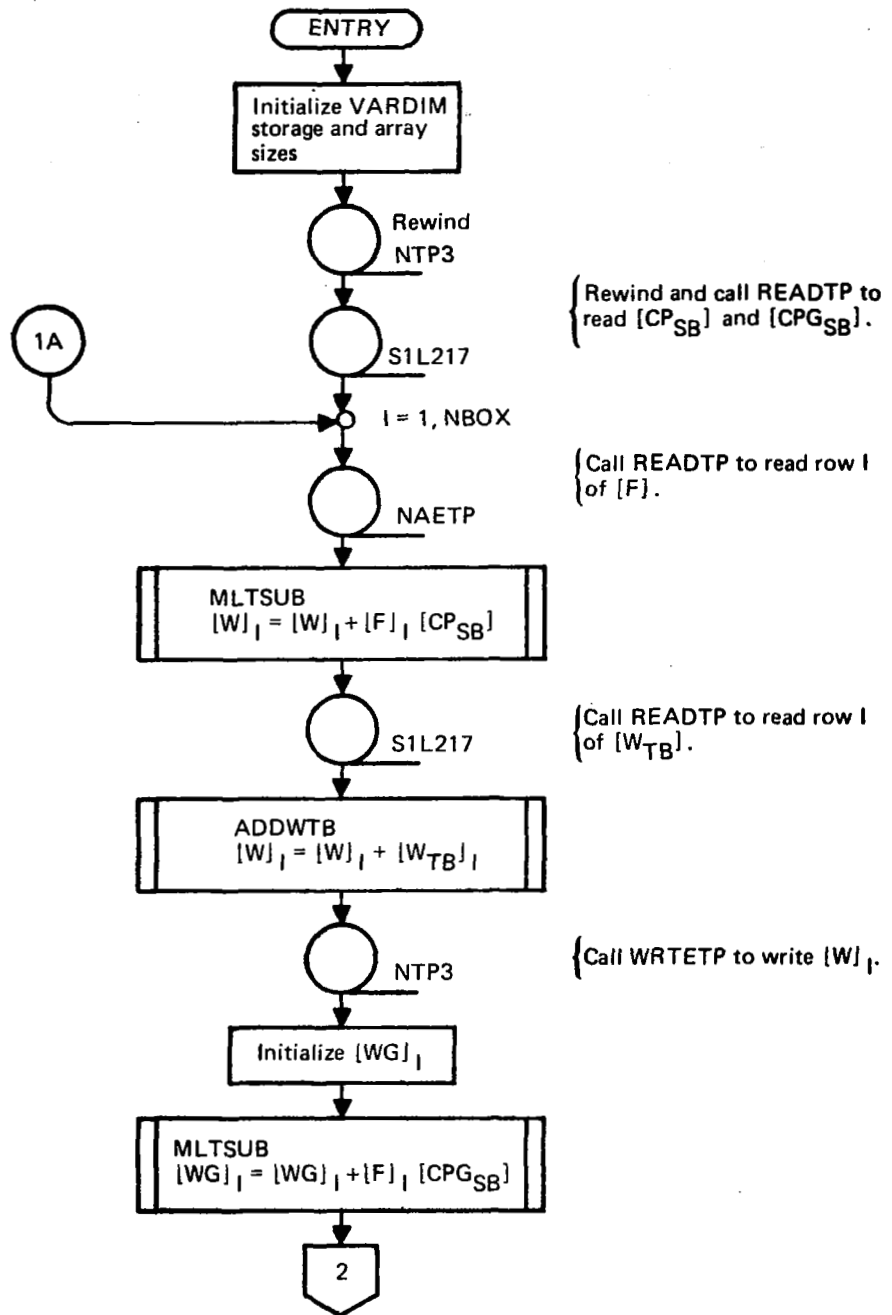


Figure 23. — Macro Flow Chart of Overlay (L217, 4, 5), FORMWS

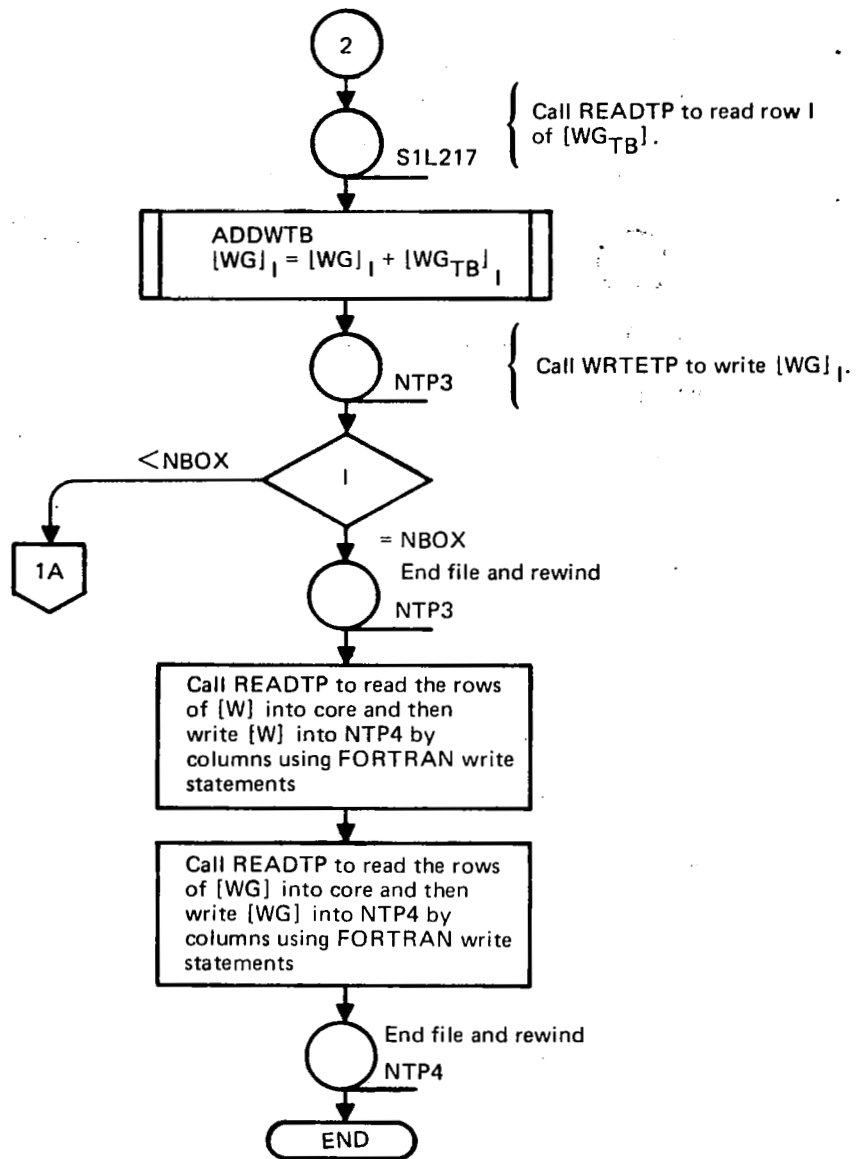


Figure 23. -- (Concluded)

*Table 18. — Routines Called by FORMWS*

OVERLAY (L2 17, 4, 5)

PROGRAM FORMWS

---

ADDWTE

DELETR+

FETAD+

FETDEL+

INITIR+

MLTSUB

PRNTCM+

READTP+

RETURNF+

SETMFL

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

### **I/O Devices of FORMWS**

FORMWS reads from the files:

NAETP      Matrix  $[F]$  by rows

S1L217      Matrices  $[CP_{SB}]$  and  $[CPG_{SB}]$

NTP3      Matrices  $[W]$  and  $[WG]$  after having written by rows

FORMWS writes onto the files:

NTP3      Matrices  $[W]$  and  $[WG]$  by rows

NTP4      Matrices  $[W]$  and  $[WG]$  by columns

#### **3.4.6 OVERLAY(L217,4,6), SOLVDW**

##### **Purpose of SOLVDW**

SOLVDW solves the following equation for  $[\Delta C_p]$ :

$$[D] [\Delta C_p] = [W/WG]$$

##### **Analytical Steps of SOLVDW**

SOLVDW performs its task in the following steps:

1. Determine available length of blank common.
2. Initialize the files NTP3, NTP4, and NTP5.
3. Call COPYDQ to copy the quasi-inverse of  $[D]$  from NAETP to NTP5.
4. Call FUTSOL to solve the equation.
5. Close scratch files and return to the calling program.

The macro flow chart of this overlay is shown in figure 24.

The routines called are displayed in table 19.

##### **I/O of SOLVDW**

SOLVDW reads from the files:

NAETP      Quasi-inverse of  $[D]$

NTP4      Right-hand-side matrices  $[W]$  and  $[WG]$  by columns

SOLVDW writes onto the file:

NTP3      Solution columns

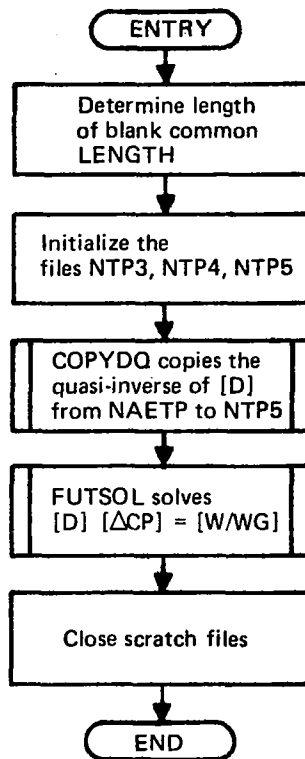


Figure 24. — Macro Flow Chart of Overlay (L217, 4, 6), SOLVDW

*Table 19. — Routines Called by SOLVDW*

OVERLAY (L217, 4, 6)

PROGRAM SOLVDW

---

COPYDQ

FETAD+

FETDEL+

FUTSOL

{ FETAD+

FETDEL+

RETURNF+

REQFL+

RETURNF+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

SOLVDW also writes/reads data on/from the files MT, NIN, NOUT, and NATAPE during the solution inside the subroutine FUTSOL.

MT = 4LFUT1

NIN = 4LFUT2

NOUT = 4LFUT3

NATAPE = 4LFUT4

### 3.4.7 OVERLAY(L217,4,7), DLAFC

#### Purpose of DLAFC

DLAFC generates aerodynamic forces based upon Doublet Lattice (L216) AIC matrices:

$$\begin{aligned} [FR] &= [F\ddot{A}C] \begin{bmatrix} [0] \\ \text{-----} \\ q[\dot{A}_{SB}] [CP_{SB}] \end{bmatrix} + q[\ddot{\Sigma}] [\dot{A}_{TB/IB}] [\Delta CP] \\ [FG] &= [F\ddot{A}C] \begin{bmatrix} [0] \\ \text{-----} \\ q[\dot{A}_{SB}] [CPG_{SB}] \end{bmatrix} + q[\ddot{\Sigma}] [\dot{A}_{TB/IB}] [\Delta CP_G] \end{aligned}$$

#### Analytical Steps of DLAFC

DLAFC performs its task in the following steps:

1. Initialize VARDIM storage and read  $\{A\}$ ,  $[\Sigma]$ ,  $[F\ddot{A}C]$ , and  $[CP_{SB}]$  into core.

Repeat step 2 for each mode.

2. Read a column of  $[\Delta Cp]$  from NTP3, call CALCFS to form a column of  $[FR]$ , and write partitions of  $[FR]$  (with IPSIZE columns) onto S3L217.

3. Initialize  $\{FG\}_{IG}$  and read  $[CPG_{SB}]$  from S1L217.

Repeat step 4 for each gust zone.

4. Read a column of  $[\Delta Cp_G]$  from NTP3, call CALCFS to form a column of  $[FG]$ , and write  $\{FG\}_{Zone}$  onto S3L217.

5. Return to the calling program.

The macro flow chart of this overlay is shown in figure 25.

The routines called are displayed in table 20.

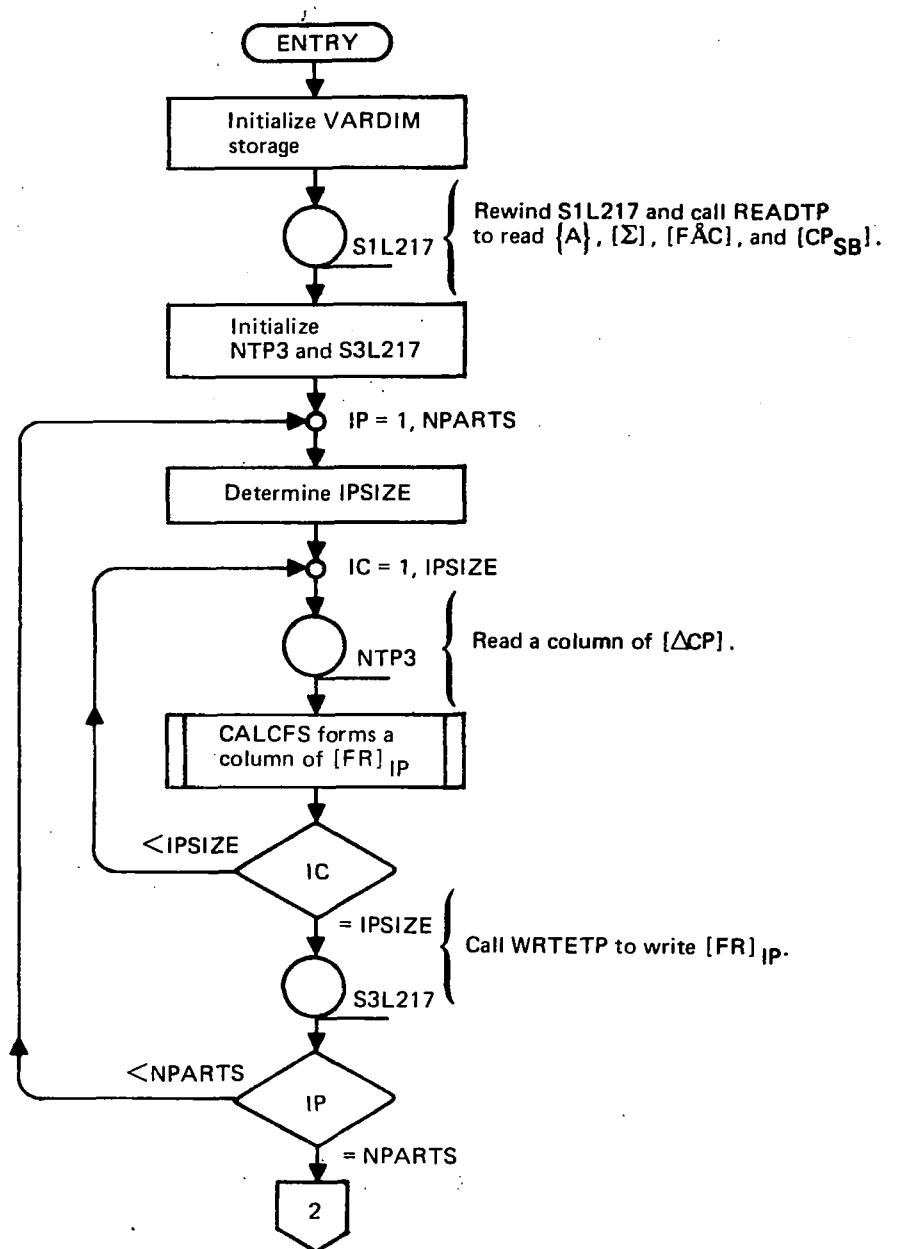


Figure 25. — Macro Flow Chart of Overlay (L217, 4, 7), DLAFCR

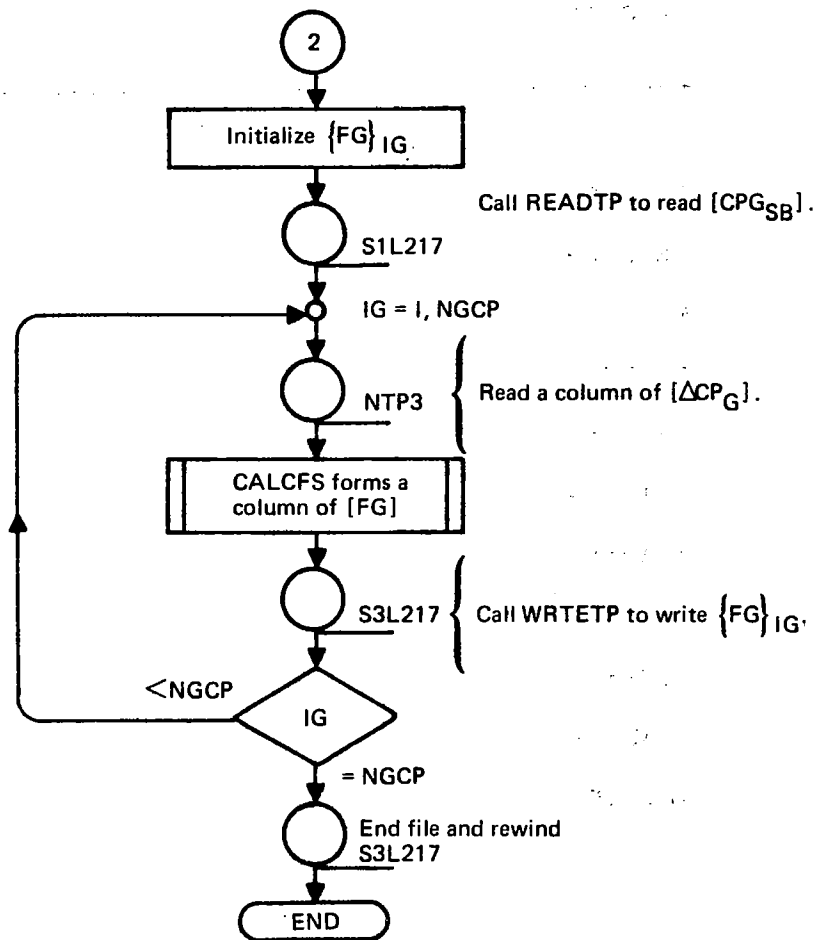


Figure 25. -- (Concluded)

Table 20. — Routines Called by DLAFRC

OVERLAY (L2 17, 4, 7)

PROGRAM DLAFRC

---

CALCFS

DELETR+

FETAD+

FETDEL+

PPNTCM+

INITIR+

READTP+

RETURNF+

SETMFL

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

### I/O Devices of DLAFCR

DLAFCR reads from the files:

S1L217      Matrices  $\{A\}$ ,  $[\Sigma]$ ,  $[FAC]$ ,  $[CP_{SB}]$ , and  $[CPG_{SB}]$

NTP3        Solution columns,  $[\Delta C_p]$  and  $[\Delta C_{pG}]$

DLAFCR writes onto the file:

S3L217      Matrices

$[FR]$  in partitions of IPSIZE columns

$[FG]$  as NGCP column matrices

### 3.4.8 OVERLAY(L217,4,10), DLAODR

#### Purpose of DLAODR

DLAODR sorts the aerodynamic force matrices according to the interpolation surface numbers specified for each element via card input data. The resulting surface force matrices are written onto EOMLOD.

The macro flow chart of this overlay is shown in figure 26.

The routines called are displayed in table 21.

### I/O Devices of DLAODR

DLAODR reads from the files:

S1L217      Matrices

$\left. \begin{array}{l} \{SURFTB\} \\ \{IPNSRF\} \\ \{X\} \\ \{Y\} \\ \{A\} \end{array} \right\} \text{ See section 3.6.3}$

S3L217      Matrices  $[FR]$  and  $[FG]$  (see sec. 3.6.3)

DLAODR writes on the file:

EOMLOD     For each surface the matrices

$\left. \begin{array}{l} [X,Y]_{IS} \\ \{A\}_{IS} \\ [F_1] \\ [F_2] \\ [FG] \end{array} \right\} \text{ See section 6.5.2} \\ \text{of volume I}$

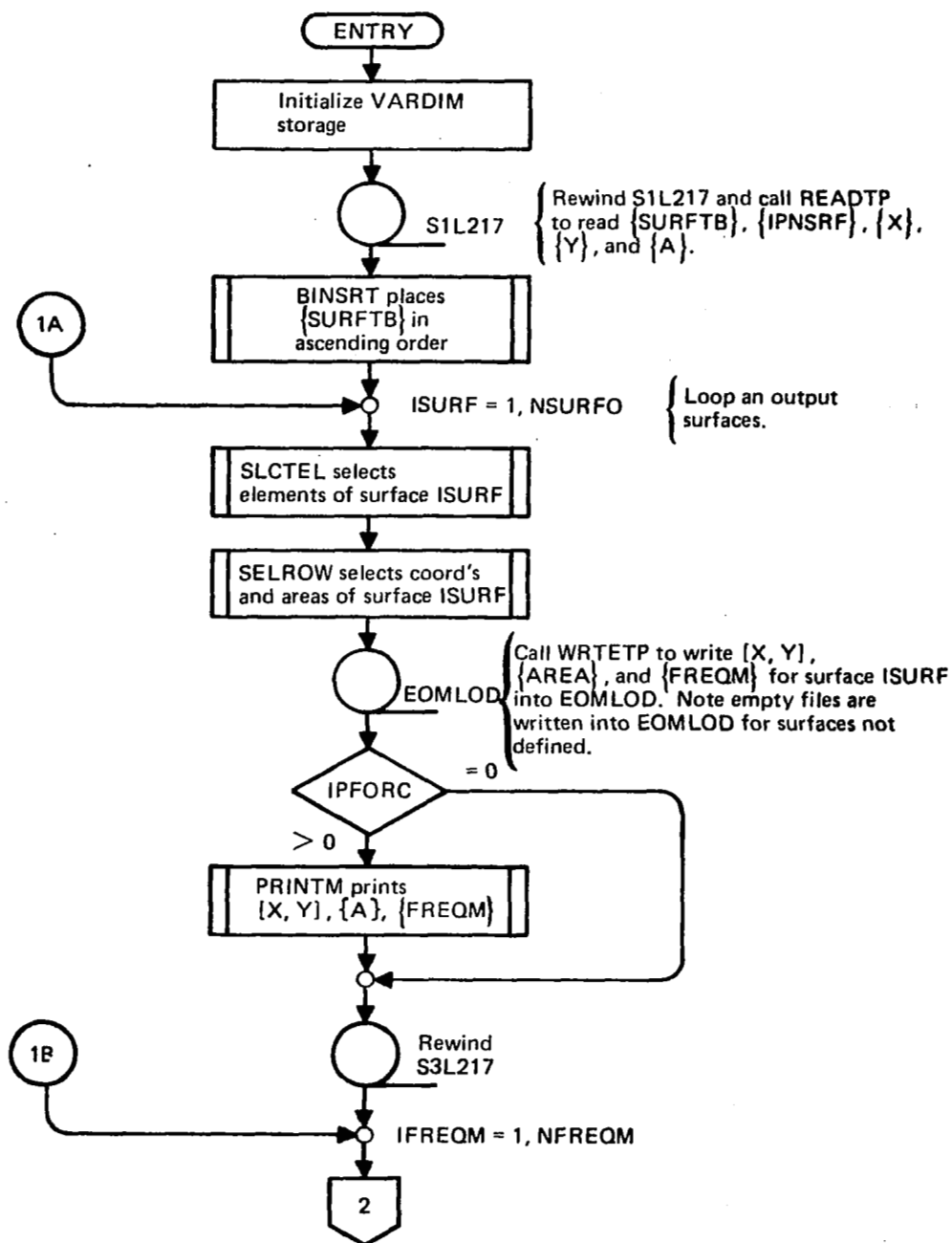


Figure 26. — Macro Flow Chart of Overlay (L217, 4, 10), DLAODR

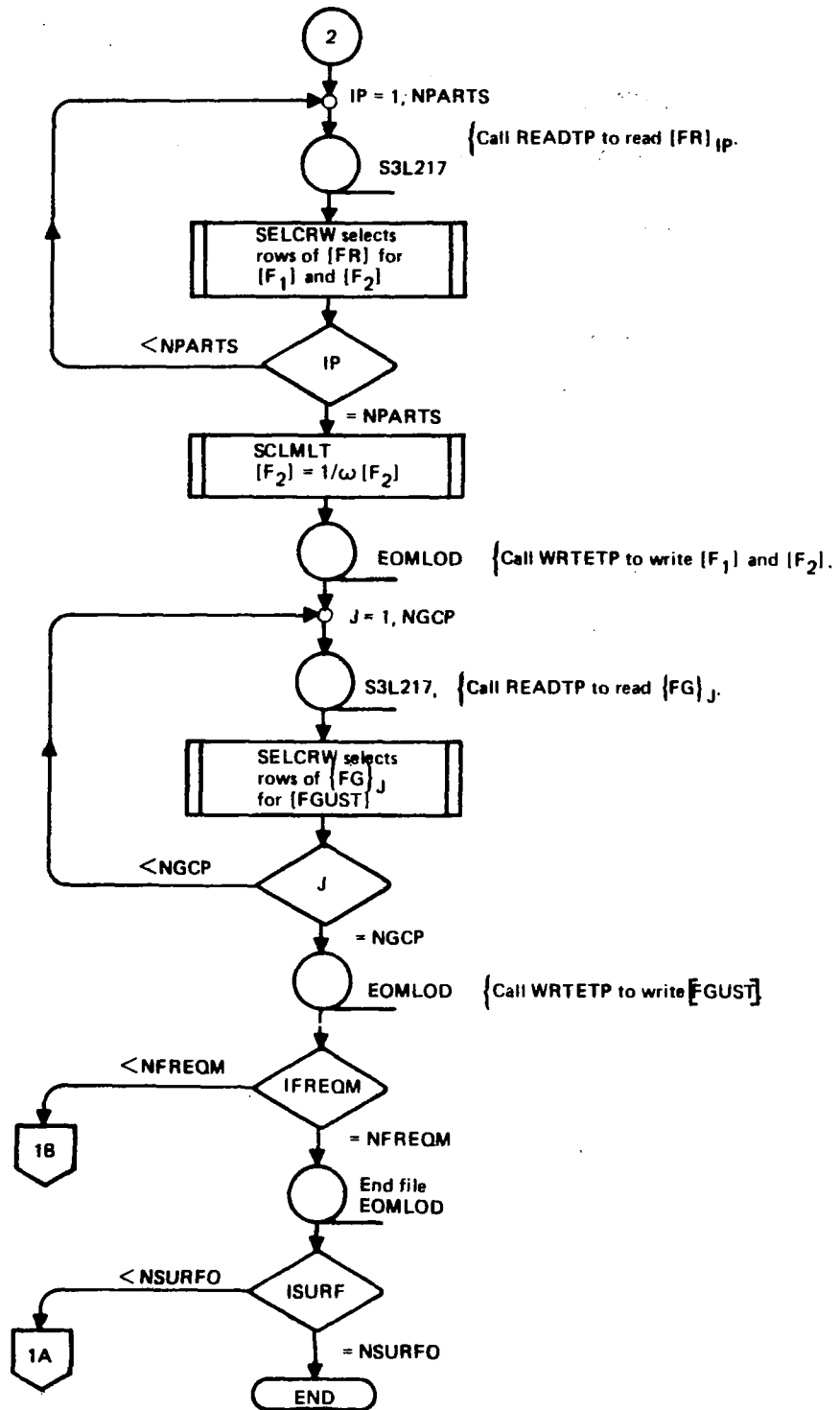


Figure 26. — (Concluded)

Table 21. — Routines Called by DLAODR

OVERLAY (L217,4,10)

PROGRAM DLAODR

---

BINSRT

DELETR+

FETAD+

FETDEL+

INITIR+

PPINTM+

PRNTCM+

READTP+

SCIMLT

SELCRW

SELROW

SETMFL

SLCTEL

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

### 3.4.9 OVERLAY(L217,4,11), DLAEOM

#### Purpose of DLAEOM

DLAEOM generates the aerodynamic equations of motion matrices ( $[M_4]$ ,  $[M_5]$ , and  $[\tilde{\phi}]$ ) and writes the file EOMTAP. The matrix equations are:

$$[M_4] = -[\phi_{FP}]^T [\overset{\circ}{SF}] [FR]_{\text{Real}}$$

$$[M_5] = -[\phi_{FP}]^T [\overset{\circ}{SF}] [FR]_{\text{Imaginary}}$$

$$[\tilde{\phi}] = [\phi_{FP}]^T [\overset{\circ}{SF}] [FG]$$

The macro flow chart of this overlay is shown in figure 27.

The routines called are displayed in table 22.

#### I/O Devices of DLAEOM

DLAEOM reads from the files:

S1L217      Matrices  $[\overset{\circ}{SF}]$  (from the first logical file) and  $[\phi_{FP}]$  (from the second logical file)

S3L217      Matrices  $[FR]$  (by partition) and  $[FG]$  (by columns)

DLAEOM writes onto the file EOMTAP the matrices:

	{HEADER}		
	$[M_1]$		
	$[M_2]$	(only if damping requested)	
	$[M_3]$		
	{FREQM}		
Repeat	{		
per frequency			$[M_4]$
			$[M_5]$
			$\{f_k\}$
		(only for first frequency)	
		$[\tilde{\phi}]$	

### 3.5 OVERLAY(L217,5,0), DLPRES

#### Purpose of DLPRES

DLPRES prepares the equations of motion file, EOMTAP, and the aerodynamic force file, EOMLOD (sec. 3.6.2). It uses aerodynamic information from Doublet Lattice (L216) (ref. 4) the generalized forces and the unsteady aerodynamic pressure.

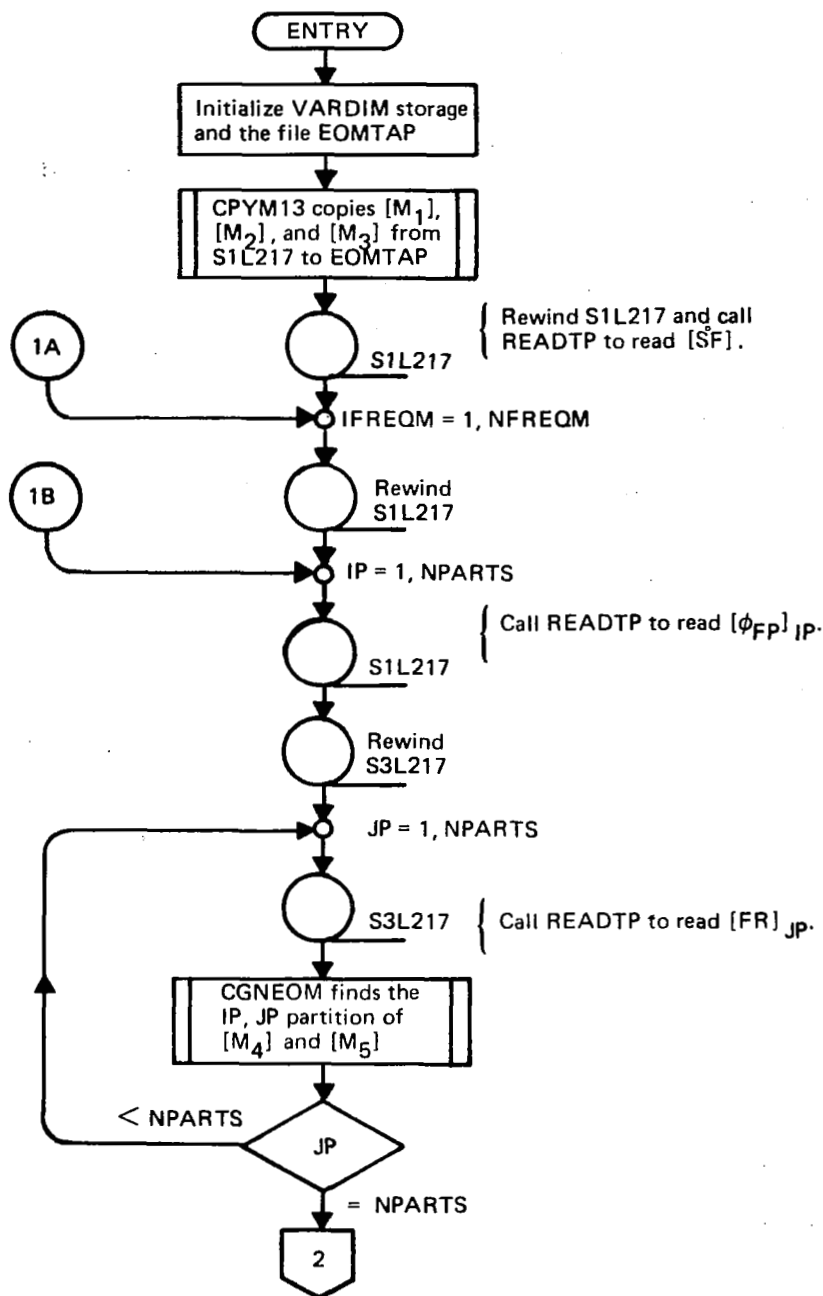


Figure 27. — Macro Flow Chart of Overlay (L217, 4, 11), DLAEOM

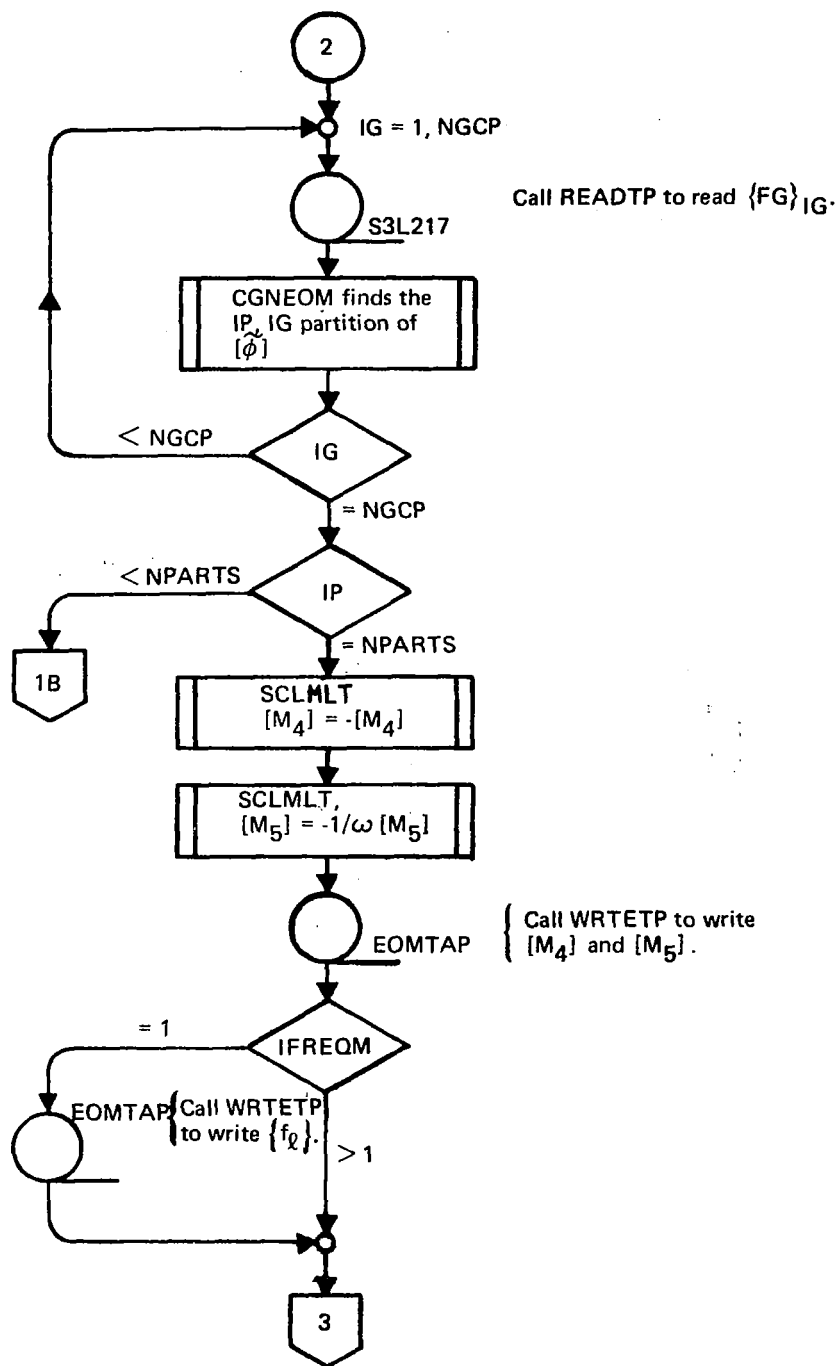


Figure 27. — (Continued)

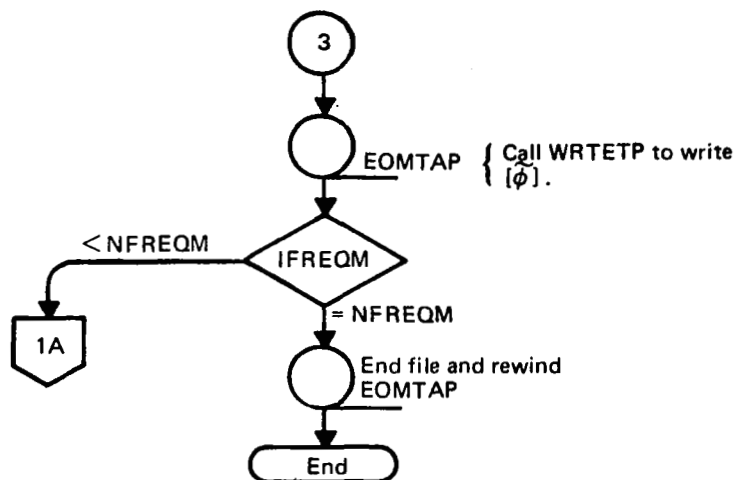


Figure 27. -- (Concluded)

Table 22. — Routines Called by DLAEOM

OVERLAY (L2 17, 4, 11)

PROGRAM DLAEOM

CGNEOM

CYPM13	{	FETAD+
		FETDEL+
		PRINTM+
		READTP+
		WRTETP+

DELETF+

FETAD+

FETDEL+

INITIR+

PRINTM+

PRNTCM+

READTP+

SCLMLT

SETMFL

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

## Analytical Steps of DLPRES

DLPRES performs its task in the following steps:

1. Print the message NOW IN DLPRES TO..., initialize the count of errors, and initialize the scratch file named S1L217.
2. Call overlay (L217,5,1), DLPCDS, to read the card input data directing the processing of Doublet Lattice (L216) generalized forces and unsteady pressures.
3. Call overlay (L217,5,2), DLPGEO, to process the Doublet Lattice (L216) geometry data and combine it with the card input data to prepare arrays directing the processing of steps 4 through 6.
4. Call overlay (L217,5,4) to generate the aerodynamic forces per reduced frequency and per mode.
5. Call overlay (L217,5,5) to sort the aerodynamic forces and write them onto EOMLOD by surface.
6. Call overlay (L217,5,6) to generate the equations of motion matrices and write them onto EOMTAP.
7. Close the scratch file S1L217 and return to the calling program.

The macro flow chart of this overlay is shown in figure 28.

The routines called are displayed in table 23.

The equations solved by DLPRES are summarized as follows:

$$[FR] = [FAC] [\tilde{\Sigma}]^* [\tilde{A}] [\Delta CP]$$

$$[F_1] = q[FR]_{\text{Real}}$$

$$[F_2] = \frac{q}{\omega} [FR]_{\text{Imaginary}} \quad (\text{if } \omega = 0, [F_2] = [0])$$

$$\{FG\} = \frac{iq}{\omega} \{FR\}_n \quad (\text{if } \omega = 0, \frac{1}{v} \text{ replaces } -\frac{iq}{\omega})$$

where n indicates column n of  $[FR]$

$$\begin{aligned} n &= \text{NTDEF if } \omega > 0 \\ n &= \text{NPDEF if } \omega = 0 \end{aligned}$$

$$[M_4] = -2q[Q]_{\text{Real}}$$

$$[M_5] = -\frac{2q}{\omega} [Q]_{\text{Imaginary}} \quad (\text{if } \omega = 0, [M_5] = [0])$$

$$\{\tilde{\phi}\} = \frac{2q}{\omega} \{Q_{\text{Imaginary}}\}_{\text{NTDEF}} - \frac{2iq}{\omega} \{Q_{\text{Real}}\}_{\text{NTDEF}} \quad (\text{when } \omega > 0)$$

$$\{\tilde{\phi}\} = \frac{2q}{v} \{Q_{\text{NPDEF}}\} \quad (\text{when } \omega = 0)$$

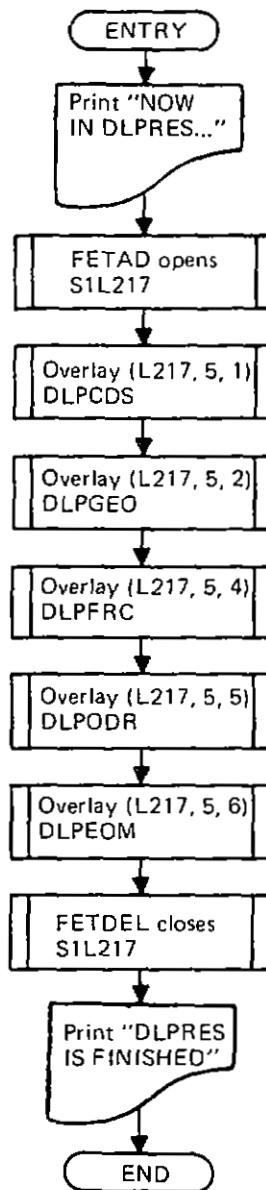


Figure 28. —Macro Flow Chart of Overlay (L217, 5, 0), DLPRES

Table 23. — Routines Called by DLPRES

OVERLAY (L217, 5, 0)

PROGRAM DLPRES

---

DLPCDS      OVERLAY (L217, 5, 1)

DLPEOM      OVERLAY (L217, 5, 6)

DLPFRC      OVERLAY (L217, 5, 4)

DLPGEO      OVERLAY (L217, 5, 2)

DLPCDR      OVERLAY (L217, 5, 5)

FETAD+

FETDEL+

+ indicates routines from the DYLOFLEX  
alternate subroutine library

## I/O Devices of DLPRES

DLPRES prints two messages on the output file; NOW IN DLPRES..., and DLPRES IS FINISHED.... All other file communication in DLPRES is performed by its secondary overlays. Figure 29 shows the files used in DLPRES' secondary overlays.

In subsections 3.5.1 through 3.5.5 the matrices read from and written onto each file are listed. (See sec. 6.4 to 6.5 of vol. I, *Engineering and Usage*, for detailed descriptions of the format and content of files for external communication.) Section 3.6.3 of this volume contains the same information for L217 (EOM)'s temporary scratch files.

### 3.5.1 OVERLAY(L217,5,1), DLPCDS

#### Purpose of DLPCDS

DLPCDS reads card input data directing the processing of Doublet Lattice (L216) generalized forces and unsteady pressures. (See card set 3.0 in vol. I of this document, *Engineering and Usage*.)

#### Analytical Steps of DLPCDS

DLPCDS performs its task in the following steps:

1. Initialize options and constants to their default values.
2. Read the constant card and extract RHO, VEL, NTDEF, and NPDEF.  
Repeat step 3 until an END card is read. Then, jump to step 4.
3. Read another data card, extract the keyword, and jump to the location which processes that card. The keywords are:

SATAP	CHECK	SLENDER
NAETP	PRINT	THIN
NGETP	SELECT	CONTROL
EOMTAP		END
EOMLOD		

- The keyword card CONTROL is recognized only after the THIN card.
  - The information from the THIN or SLENDER card is stored in the array IBDTAB and written onto the file S1L217.
  - The panels specified after a CONTROL card are stored in the array ICSTAB and written onto the file S1L217.
4. Write and end of file onto the file S1L217.

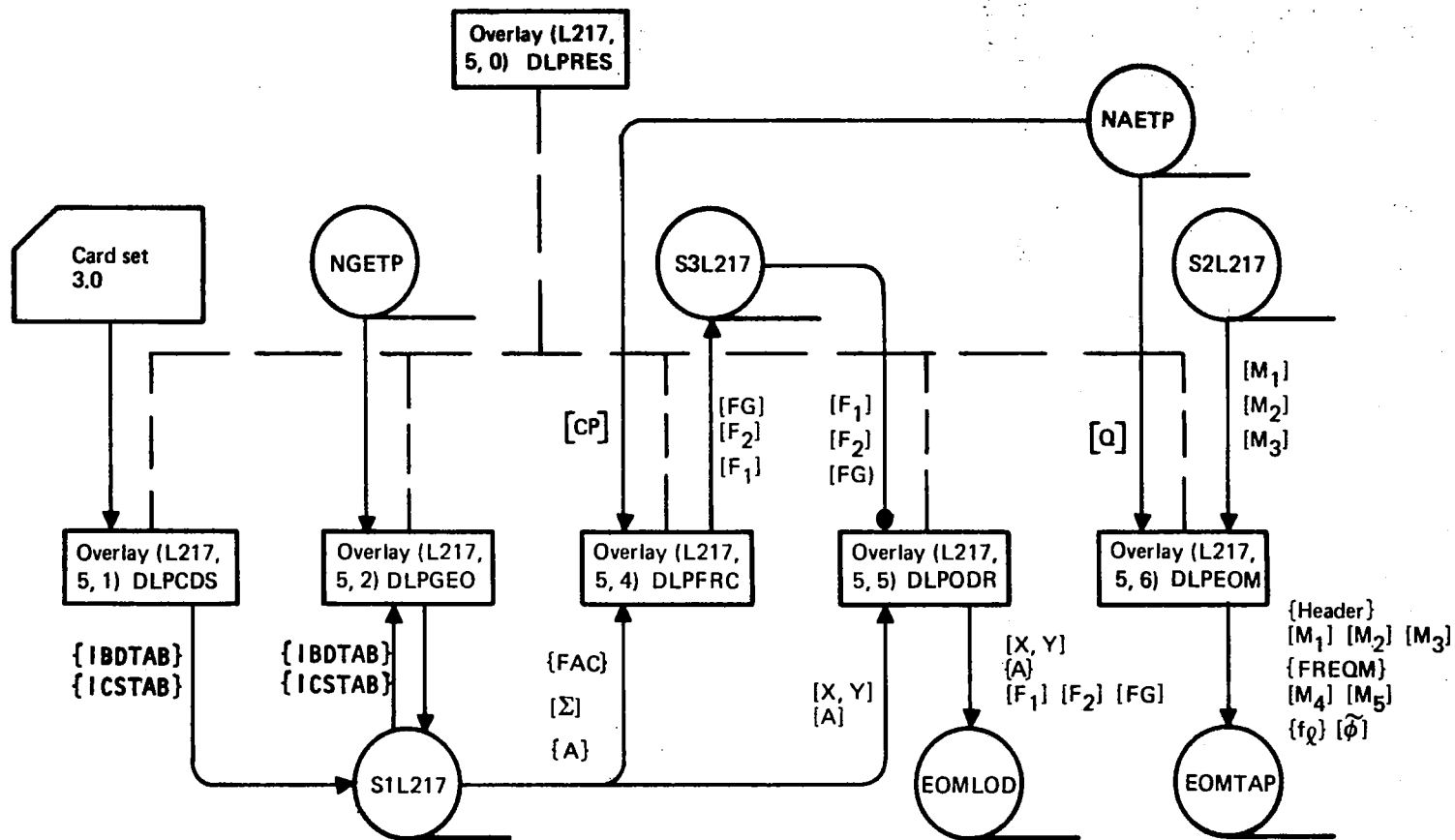


Figure 29. —Files Providing Input/Output to DLPRES Overlays

5. Return to the calling program.

The macro flow chart of this overlay is shown in figure 30.

The routines called are displayed in table 24.

### **I/O Devices of DLPCDS**

DLPCDS reads all of the card input data directing the processing of Doublet Lattice (L216) generalized forces and unsteady pressures.

It prints all of the card images, additional descriptive comments, and diagnostics for all errors discovered.

DLPCDS writes arrays of surface data onto the file S1L217. The arrays are {IBDTAB} and {ICSTAB}. See section 3.6.3 for the exact format and content of S1L217.

### **3.5.2 OVERLAY(L217,5,2), DLPGEO**

#### **Purpose of DLPGEO**

DLPGEO reads the Doublet Lattice (L216) geometry data from the file NGETP, combines it with the card input data read from S1L217, and prepares geometry arrays governing the calculation of aerodynamic forces. The arrays prepared are written onto the first logical file of S1L217 (see sec. 3.6.3).

#### **Analytical Steps of DLPGEO**

DLPGEO performs its tasks in the following steps:

1. Initialize geometry arrays and counters.
2. Call RDLGEO to read the Doublet Lattice (L216) geometry data from the file NGETP.

Rewind S1L217, then repeat steps 3 through 5 for each body (thin or slender) defined via card input to DLPCDS; IBOD = 1, NBOD.

3. Read from S1L217 the array {IBDTAB}<sub>IBOD</sub>, the card input data associated with the body. If control surfaces are attached to the body, the array {ICSTAB} is read from S1L217 to define the aerodynamic elements on each of the control surfaces.
4. Add to the array {ISURF} and build the IBOD portion of the array {IPNSRF}.

{ISURF}      A table of modal interpolation surfaces

{IPNSRF}      A table providing a correspondence between aerodynamic elements and modal interpolation surfaces

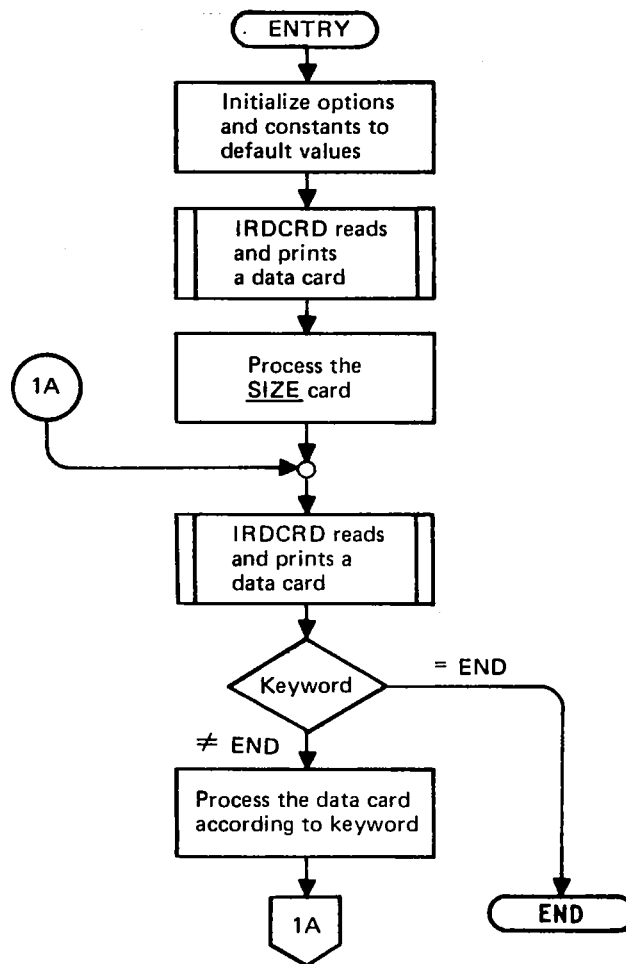


Figure 30. —Macro Flow Chart of Overlay (L217, 5, 1), DLPCDS

*Table 24. — Routines Called by DLPCDS*

OVERLAY (L217, 5, 1)

PRORAM DLPCDS

---

FNDKEY+

IRDCRD+

NAMFIL+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

5. Build the IBOD portion of the arrays:

- [F<sup>o</sup>AC]      Used to double the force of slender body elements on the plane of symmetry
- [S<sup>o</sup>F]      Used to double the force on elements off the plane of symmetry
- {IGUSTZ}    Indicates that all elements are in gust gradual penetration zone number one. Gradual penetraton is not allowed in DLPRES.

6. Build the array [SIGMA] to define the correspondence between interference body elements and slender body segments. The [SIGMA] is used to add the interference body forces to the slender body segments.

7. Call PRTGFP to print the Doublet Lattice (L216) force point geometry.

8. Transform the reference axis coordinates of all bodies to local structural coordinates using the subroutine GTOLT.

9. Compress the geometry arrays from NTOTF to NAFP elements by eliminating all interference body element entries.

NTOTF = Total number of focal points.

NAFP = Number of aerodynamic force points on all slender and thin bodies.

10. Call WRTGEO to write geometry arrays onto the file S1L217 (see sec. 3.6.3).

11. Return to the calling program.

The macro flow chart of this overlay is shown in figure 31.

The routines called are displayed in table 25.

### I/O Devices of DLPGEO

DLPGEO reads the Doublet Lattice (L216) geometry data from the file NGETP (see sec. 6.4.4 of vol. I).

DLPGEO reads the arrays {IBDTAB} and {ICSTAB} from S1L217. They contain the card input data read by DLPCDS.

DLPGEO prints the geometry arrays and then writes them onto the file S1L217.

### 3.5.3 OVERLAY(L217,5,4), DLPFRC

#### Purpose of DLPFRC

DLPFRC calculates the complex aerodynamic forces on the structural elements (the thin body boxes and slender body segments). Note that the interference body forces are

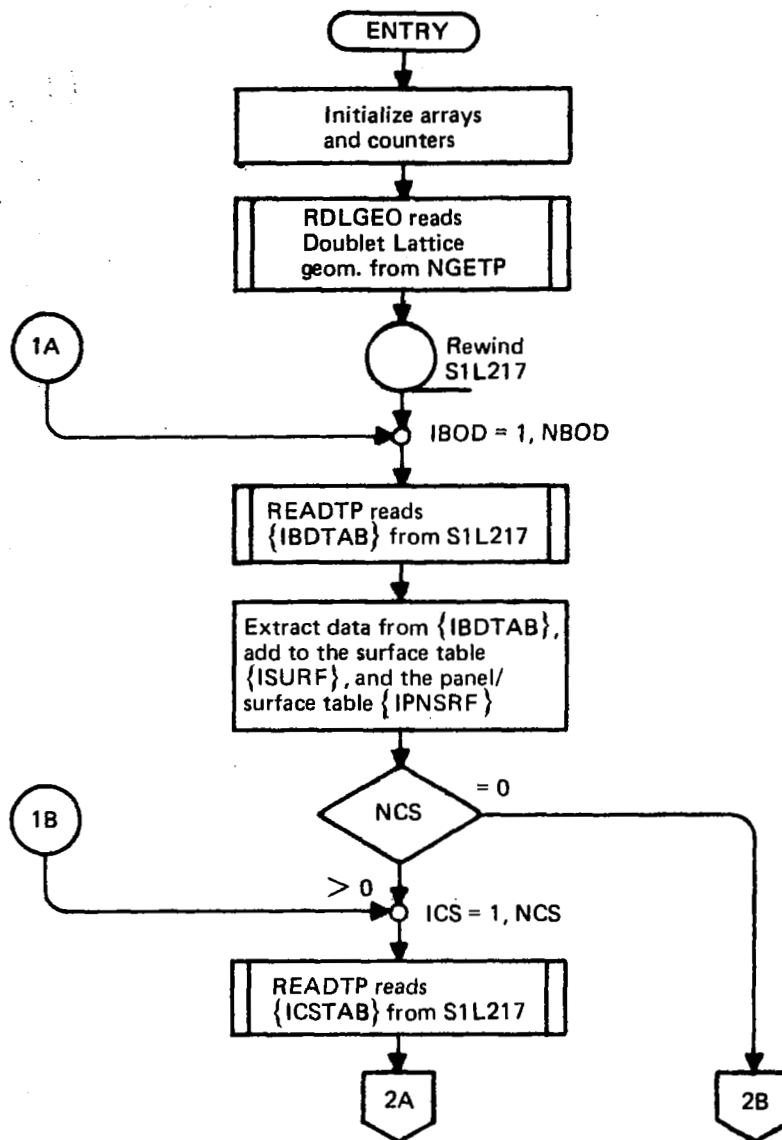


Figure 31. —Macro Flow Chart of Overlay (L217, 5, 2), DLPGEO

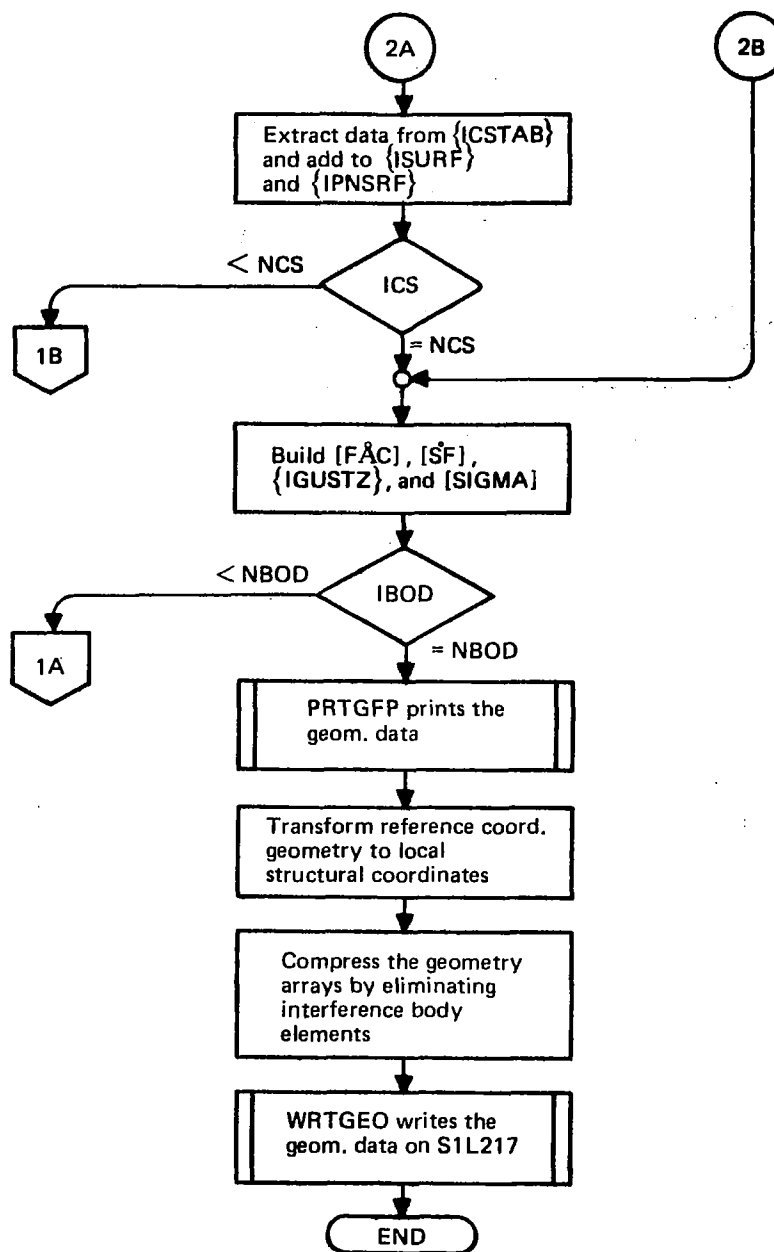


Figure 31. —(Concluded)

Table 25. — Routines Called by DLPGEO

OVERLAY (L217, 5, 2)

PFOGRAM DLPGEO

-----  
GTOLT+

IRQL+

PRTGFP

PDLGEO	{	FETAD+
		FETDEL+
		READTP+

WRTGEO	WRTETP+
--------	---------

+ indicates a routine from the DYLOFLEX alternate subroutine library

included in the slender body segment forces by the summation matrix  $[\Sigma]$  in the following equation:

$$[F_{12}]_k = [F\ddot{A}C][\ddot{\Sigma}][\ddot{A}][\Delta CP]_k$$

$k = 1, \text{NFREQM}$  (the number of reduced frequencies)

### Analytical Steps of DLPFRC

DLPFRC performs its task in the following steps:

1. Initialize VARDIM storage, arrays, and counters.
2. Read  $[A]$ ,  $[\Sigma]$ , and  $[F\ddot{A}C]$  from S1L217.
3. Read the  $\{ACM\}$ , the aerodynamic control matrix, from NAETP and extract the reduced frequencies.

Repeat steps 4 through 7 for each reduced frequency.

4. Skip the  $[F]$  and  $[D]$  quasi-inverse matrices if they are on NAETP.

Repeat steps 5 through 7 for each mode; IDOF = 1, NDOF.

5. Read  $\{\Delta CP\}_{IDOF}$  from NAETP.
6. Call subroutines CEQAC, SUMFRC, and CEQAC again to form

$$\{F_{12}\}_{IDOF} = [F\ddot{A}C][\ddot{\Sigma}][\ddot{A}]\{\Delta CP\}.$$

7. Call WRTETP to write  $\{F_{12}\}_{IDOF}$  onto S3L217.
8. Close the scratch files and return to the calling program.

The macro flow chart of this overlay is shown in figure 32.

The routines called are displayed in table 26.

### I/O Devices of DLPFRC

DLPFRC reads from the files:

NAETP	$\{ACM\}$	Aerodynamic control matrix
	$[\Delta CP]$	Complex unsteady pressure matrix by columns.

(See sec. 6.4.5 of vol. I and ref. 4 for a detailed description of NAETP contents.)

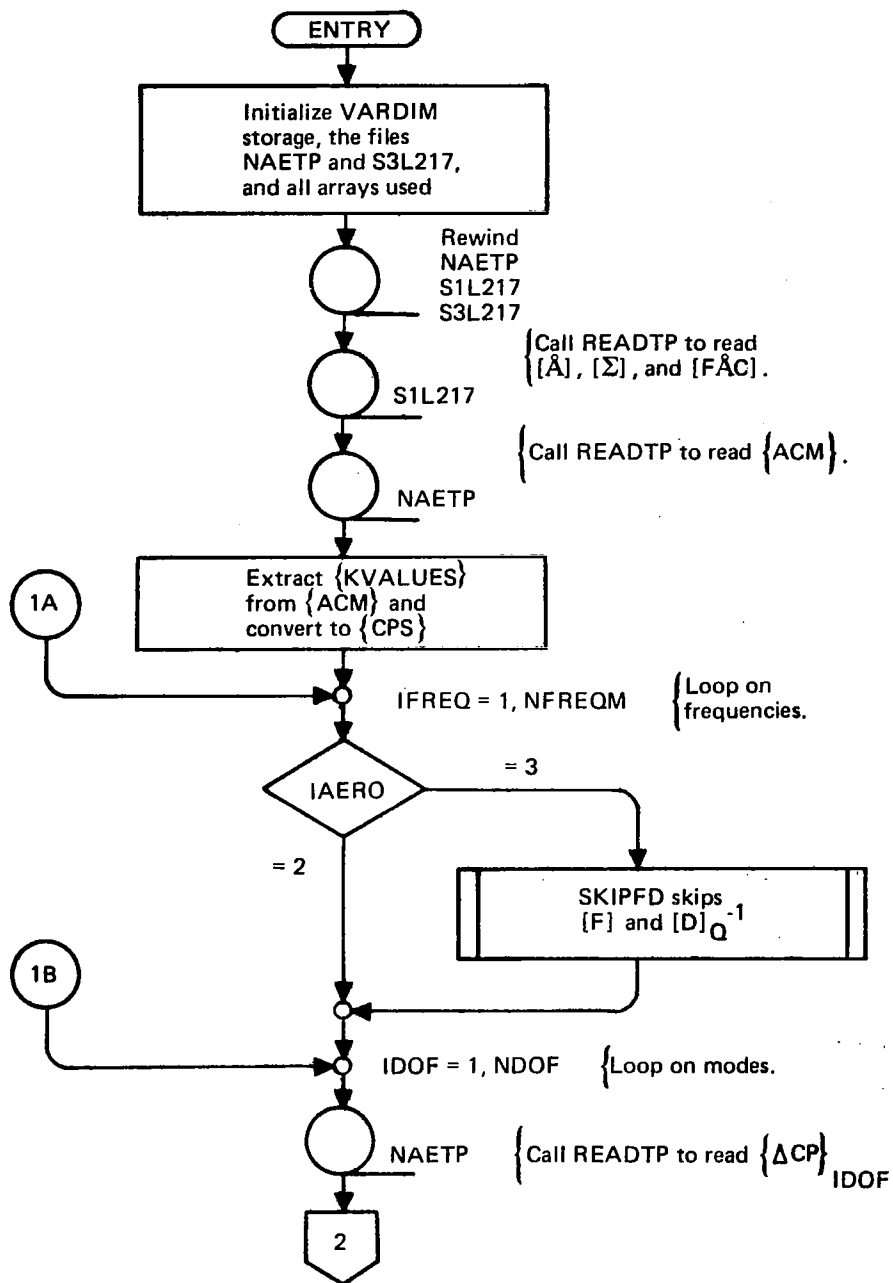


Figure 32. --Macro Flow Chart of Overlay (L217, 5, 4), DLPFRC

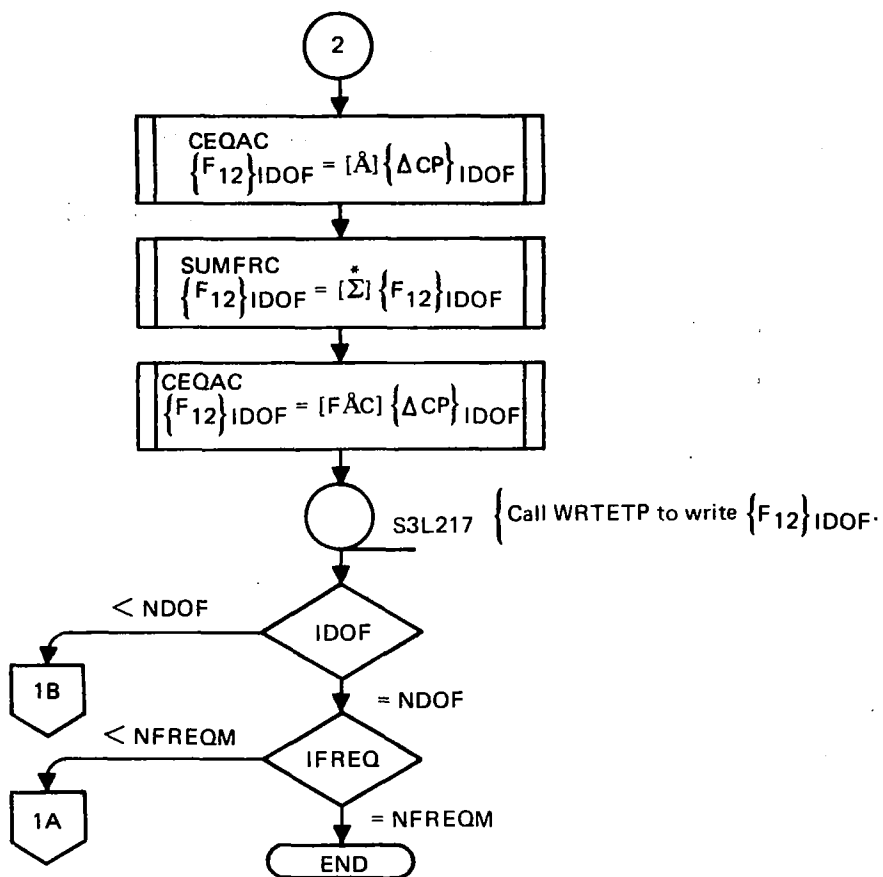


Figure 32. —(Concluded)

*Table 26. — Routines Called by DLPFRC*

OVERLAY (L217, 5, 4)

PROGRAM DLPFRC

---

CEQAC

FETAD+

FETDEL+

INITIR+

READTP+

SETMFL

SKIPFD

STARTR+

SUMFRC

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

S1L217     $\mathring{A}$       Aerodynamic element areas  
               $\Sigma$       Force summation matrix  
               $\mathring{FAC}$     Array to double the forces on slender body elements on the plane  
                                  of symmetry

DLPFRC writes onto the file:

S3L217     $F_{12}$       Unsteady aerodynamic forces on thin body boxes and slender body  
                                  segments  
                                  Matrix is written by columns and repeated per reduced frequency

### 3.5.4 OVERLAY(L217,5,5), DLPODR

#### Purpose of DLPODR

DLPODR sorts the aerodynamic force matrices according to the interpolation surface numbers specified for each element via card input data. The resulting surface force matrices are written onto the file EOMLOD.

The macro flow chart of this overlay is shown in figure 33.

The routines called are displayed in table 27.

#### I/O Devices of DLPODR

DLPODR reads from the file:

S1L217    {SURFTB} Interpolation surface table  
              {IPNSRF} Panel/surface correspondence table  
              {X}      X-coordinates of aerodynamic force points  
              {Y}      Y-coordinates of aerodynamic force points  
              {A}      Aero element areas  
               $F_{12}$       Complex aerodynamic forces at thin and slender body force  
                                  points

DLPODR writes on EOMLOD for each interpolation surface IS the following matrices:

$[X,Y]_{IS}$       Local coordinates of the surface's force points  
 $\{A\}_{IS}$       Areas of surface IS elements  
 $[F_1]$       Real part of aero forces on surface IS  
 $[F_2]$       Imaginary part of aero forces on surface IS  
 $[FG]$       Complex matrix of gust forces on surface IS

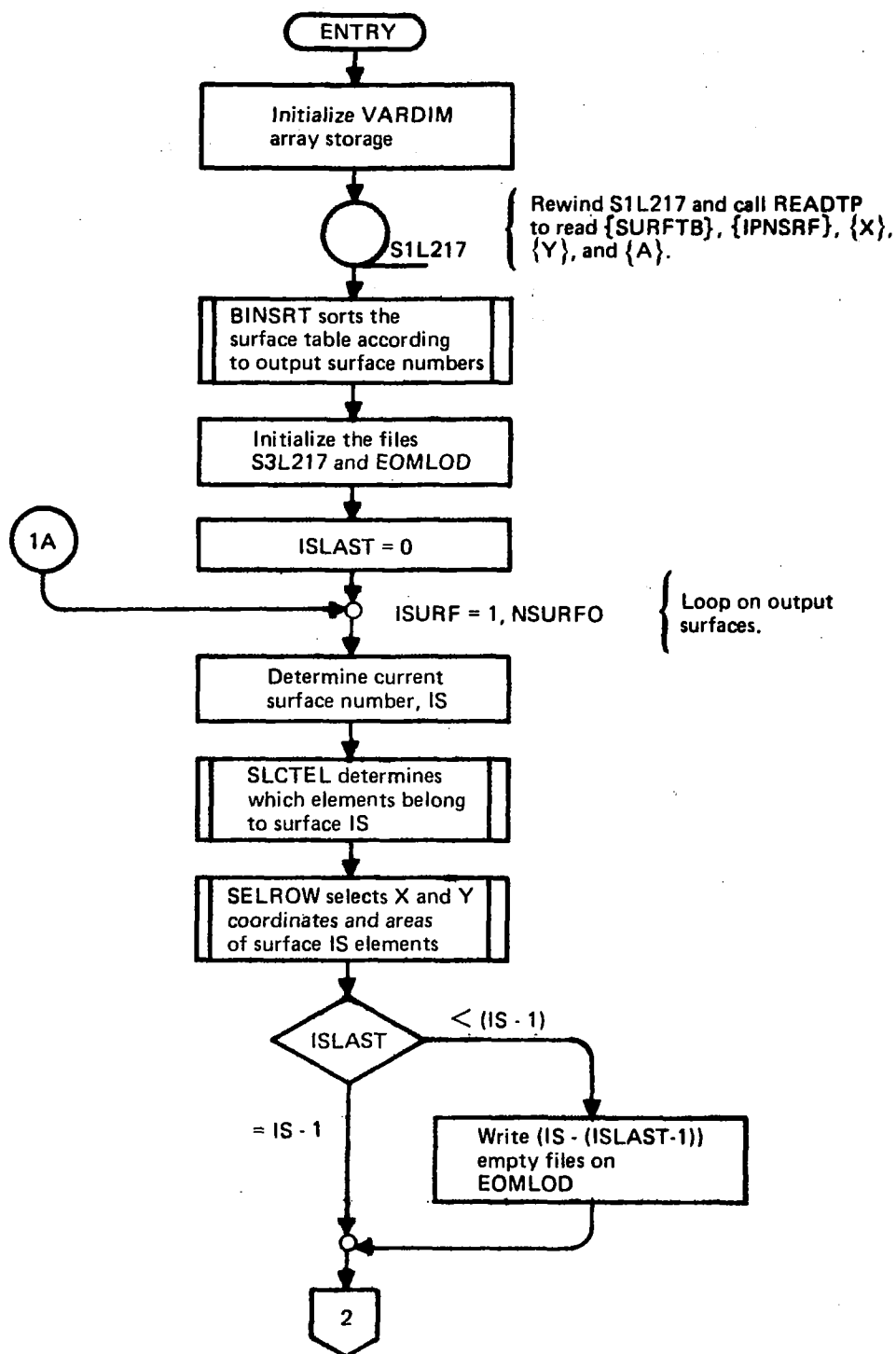


Figure 33. —Macro Flow Chart of Overlay (L217, 5, 5), DLPODR

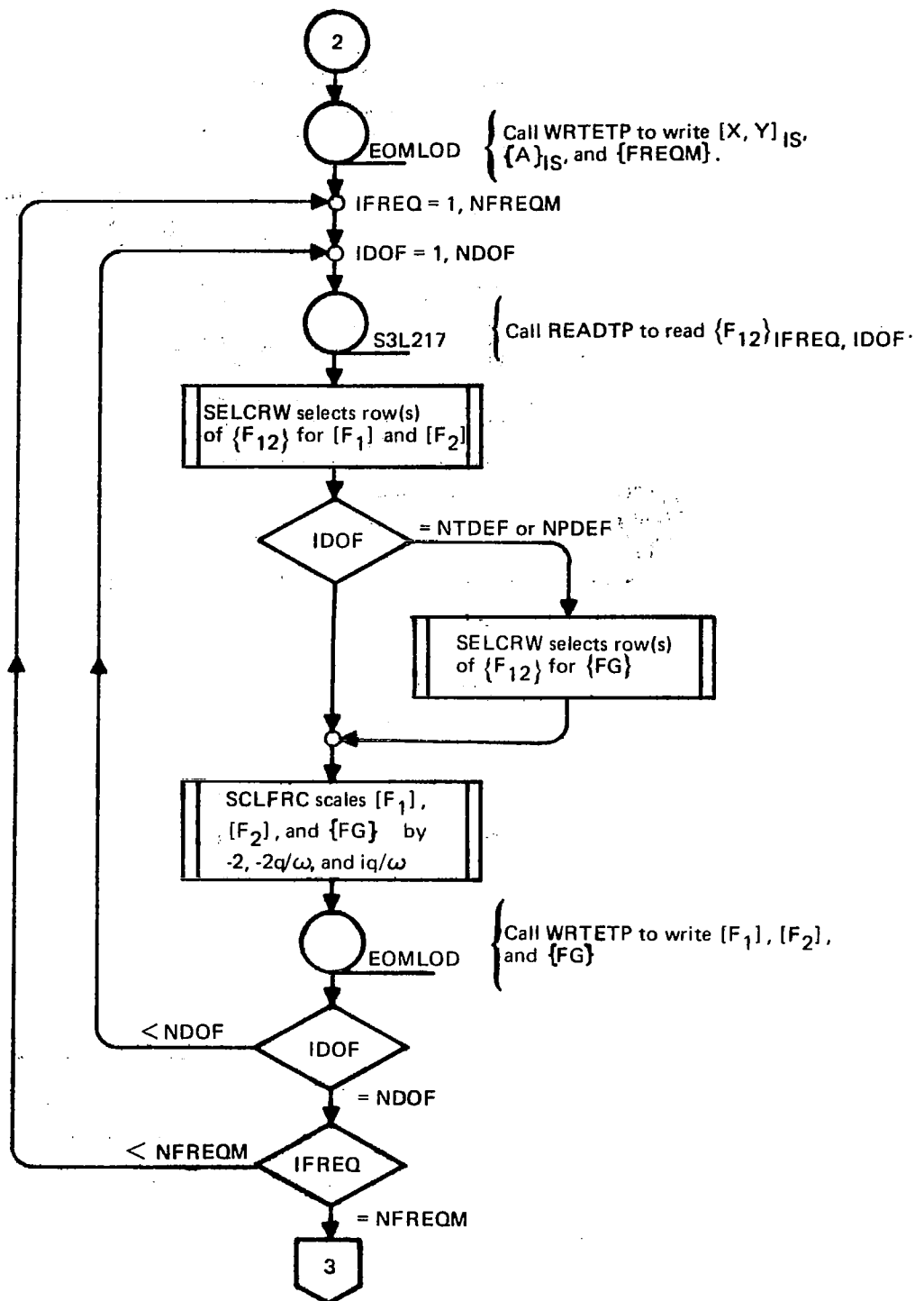


Figure 33. --(Continued)

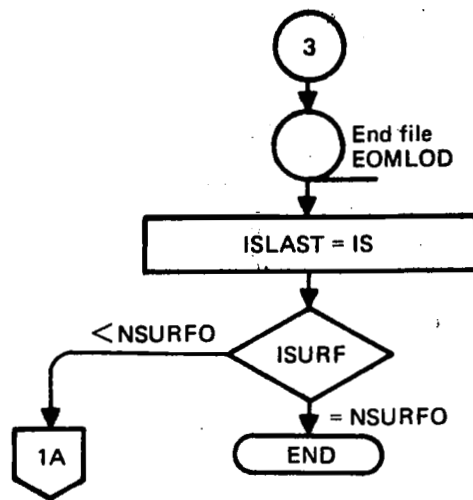


Figure 33. -- (Concluded)

*Table 27. — Routines Called by DLPODR*

OVERLAY (L2 17, 5, 5)

PROGRAM DLPODR

---

BINSRT

DELETR+

FETAD+

FETDEL+

INITIR+

PRINTM+

PRNTCM+

READTP+

SCLFRC

SELCRW

SELROW

SETMFL

SICTEL

STARTR+

WRTETP+

+ indicates routines from the DYLOFLEX  
alternate subroutine library

### 3.5.5 OVERLAY(L217,5,6), DLPEOM

#### Purpose of DLPEOM

DLPEOM generates the file EOMTAP containing the equations of motion coefficient matrices. The aerodynamic matrices ( $[M_4]$ ,  $[M_5]$ , and  $[\tilde{\phi}]$ ) are based upon the Doublet Lattice (L216) (ref. 4) generalized forces.

$$[M_4] = -2[Q_{\text{Real}}]$$

$$[M_5] = -\frac{2}{\omega}[Q_{\text{Imaginary}}]$$

$$[\tilde{\phi}] = \frac{2q}{v}\{Q_{\text{Real}}\}_{\text{NPDEF}} \text{ (when } \omega = 0.0\text{)}$$

$$[\tilde{\phi}] = \frac{2q}{\omega}\left(\{Q_{\text{Imaginary}}\}_{\text{NTDEF}} - i\{Q_{\text{Real}}\}_{\text{NTDEF}}\right) \text{ (when } \omega \neq 0.0\text{)}$$

where  $[Q]$  = the generalized air force matrix from Doublet Lattice (L216)

The macro flow chart of this overlay is shown in figure 34.

The routines called are displayed in table 28.

#### I/O Devices of DLPEOM

DLPEOM reads from the files:

NAETP	$[Q]$	Complex matrix of generalized forces from Doublet Lattice (ref. 4)
S2L217	$[M_1]$	Generalized stiffness matrix
	$[\dot{M}_2]$	Generalized damping matrix (optional)
	$[M_3]$	Generalized mass matrix

DLPEOM writes onto the file

EOMTAP	{HEADER}	DYLOFLEX header matrix introducing following arrays
	$[M_1]$	
	$[\dot{M}_2]$	From S2L217 above
	$[M_3]$	
	{FREQM}	Frequencies at which aerodynamics are defined
	$\{M_4\}$	Aerodynamic force matrices
	$\{M_5\}$	
	$\{f_l\}$	Distance to gust zones
	$[\tilde{\phi}]$	Gust force matrix

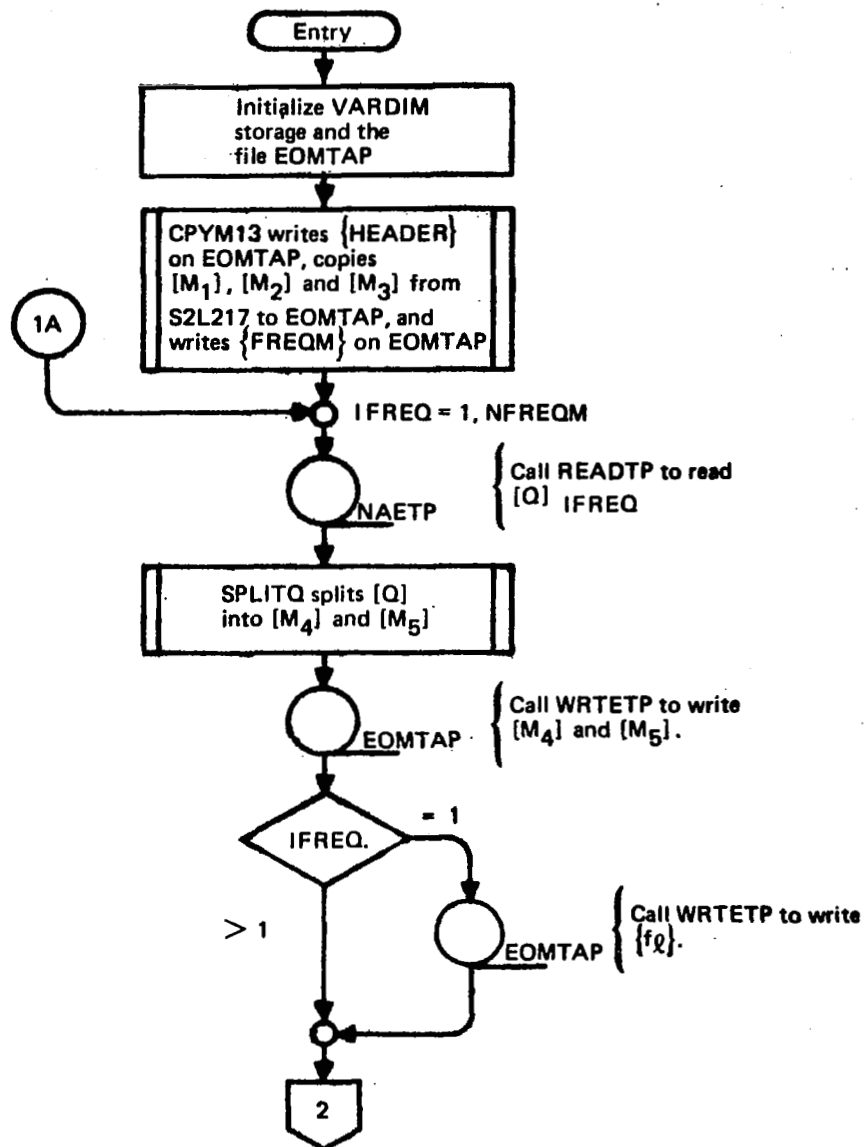


Figure 34. —Macro Flow Chart of Overlay (L217, 5, 6), DLPEOM

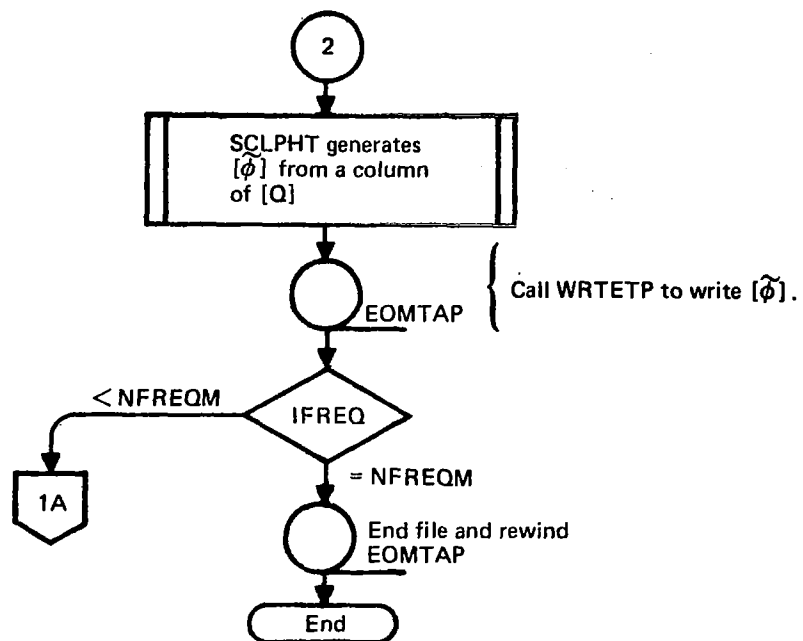


Figure 34. —(Concluded)

Table 28. — Routines Called by DLPEOM

OVERLAY (L217, 5, 6)

PROGRAM DLPEOM

---

CPYM13	{	FETAD+
		FETDEL+
		PRINTM+
		READTP+
		WRTETP+

DELETR+

FETAD+

FETDEL+

INITIR+

PRINTM+

PRNTCM+

READTP+

SCLPHT

SETMFL

SKIPFD

SPLITQ

STARTR+

WRTETP+

+ indicates a routine from the DYLOFLEX  
alternate subroutine library

### 3.6 DATA BASES

The program's data bases include input and output files plus internal scratch (temporary) storage files and common blocks.

#### 3.6.1 INPUT DATA

Data is input to the program in two forms; data cards and magnetic files.

##### Card Input Data

For a complete description of L217 (EOM) card input data, see section 6.3 in volume I of this document.

##### Magnetic File Input Data

For a complete description of L217 (EOM) disk or tape input data, see section 6.4 in volume I of this document.

The files read are:

KTAPE(GSTIF)		NGETP	from L216 (DUBFLX)
MTAPE(GMASS)		GDTAPE	from FLEXSTAB
SATAP	from L215 (INTERP)	SDSSTP	from FLEXSTAB
NAETP	from L216(DUBFLX)		

#### 3.6.2 OUTPUT DATA

The results of a L217 (EOM) run will be printed, and written on magnetic files.

##### Printed Output Data

For a complete description of the printed output data, see section 6.5.1 in volume I of this document.

##### Magnetic File Output Data

For a complete description of L217 (EOM) disk or tape output data, see section 6.5.2 in volume I of this document. The files written are:

EOMTAP  
EOMLOD

#### 3.6.3 INTERNAL DATA

Two methods are used to pass data from one portion of the program to another. They are labelled common blocks and scratch (temporary) storage disk files.

## Magnetic Disk Files

L217 (EOM) uses 10 disk files for temporary (scratch) storage of data. The files are:

S1L217, S2L217

S3L217

NTP3, NTP4, NTP5, MT, NIN, NOUT, and NATAPE

The first two files are used in all L217 primary overlays. The S3L217 is used in all aerodynamic primary overlays. The other files are used only in DLAIC when solving the system of complex simultaneous equations. All scratch files are released before L217 (EOM) terminates execution.

The first three files are always written with the subroutine WRTETP and read with the subroutine READTP. The READTP/WRTETP format is described in reference 1. The other files are written with unformatted FORTRAN write statements.

### S1L217

The scratch file named S1L217 may contain several logical files of data, each terminated by an end of file (EOF). The data on S1L217 is always in the READTP/WRTETP format. The matrices existing on the file vary according to which overlay was executed last (see figs. 35 through 39).

The following matrices are written onto S1L217 inside STRUCT's secondary overlays:

[CSDATA]      Data for a control surface adding freedoms. Each row of CSDATA represents a control surface node and contains six numbers as input on card 2.9.1.

$$\left. \begin{array}{l} X \\ Y \\ Z \end{array} \right\} \text{Coordinates of control surface node}$$

$m$  = Mass

$I_y$  = Moment of inertia about local y-axis

$I_x$  = Moment of inertia about local x-axis

$$[A] = [\phi_{CS}]^T [\dot{MCS}] [\phi_{ST}]$$

$$[C] = [\phi_{CS}]^T [\dot{MCS}] [\phi_{CS}]$$

All of the data listed in figure 35 is released just before overlay (L217,2,0), STRUCT terminates execution.

The S1L217 written by overlays (L217,3,1), FLXCDS

(L217,4,1), DLACDS

(L217,5,1), DLPCDS

Matrix Size	Matrix	
$\text{NDOF}_{\text{ST}} \times \text{NDOF}_{\text{ST}}$	[M]	} Original generalized mass matrix written in RSTRCT only if read from cards.
	EOF	
$\text{NDOF}_{\text{ST}} \times \text{NDOF}_{\text{ST}}$	[K]	} Original generalized stiffness matrix written in RSTRCT only if read from cards.
	EOF	
$\text{NDOF}_{\text{ST}} \times 1$	{g <sub>SD</sub> }	} Damping factors written in RSTRCT only if read from cards.
	EOF	
$\text{NNODE}_1 \times 6$	[CSDATA] <sub>1</sub>	} Written in RSTRCT only if cards specifying control surface freedoms were read.
$\text{NNODE}_2 \times 6$	[CSDATA] <sub>2</sub>	
$\vdots$	$\vdots$	
$\text{NNODE}_{\text{NCSEF}} \times 6$	[CSDATA] <sub>NCSEF</sub>	
	EOF	} NCSEF = number of control surfaces adding freedoms
$\text{NDOF}_{\text{CS}} \times \text{NDOF}_{\text{ST}}$	[A]	
$\text{NDOF}_{\text{CS}} \times \text{NDOF}_{\text{CS}}$	[C]	
	EOF	

Figure 35. — S1L217 at the End of Overlay (L217,2,3), Form13

Matrix	Size	Matrix	Description
NSURF	X 1	{SURFTB}	Surface Table
NAFP	X 1	{IPNSRF}	Force Point/Surface Table
NAFP	X 1	{X}	Force Point x-coordinates
NAFP	X 1	{Y}	Force Point y-coordinates
NACP	X 1	{IPNSCP}	Control Point/Surface Table
NACP	X 1	{XCP}	Control Point x-coordinates
NACP	X 1	{YCP}	Control Point y-coordinates
NTOTF	X 1	{ $\overset{\circ}{A}$ }	Areas of all aero elements
NTOTF	X 4	[SIGMA]	Force summation matrix ( $[\Sigma]$ )
NAFP	X 1	{ $\overset{\circ}{FAC}$ }	Array of 1's and 2's to double force of slender body elements on the P.O.S.
NACP	X 1	{GC}	Array of integer numbers indicating the gust zone of each control point.
NAFP	X 1	{ $\overset{\circ}{SF}$ }	Array of 1's and 2's to double force of elements off the P.O.S.
NACP	X 1	{ $\overset{\circ}{RG}$ } **	Gust rotation matrix
NSBFP	X 1	{ $\overset{\circ}{R}$ } *	Slender body segment midpoint radii
NSBFP	X 1	{ $\overset{\circ}{R'}$ } *	Slender body segment midpoint radius slopes.
EOF			

\* Meaningless with FLEXSTAB data

\*\*Meaningless except with Doublet

Lattice (L216) AIC data

Figure 36. — S1L217 Logical File 1 After a Geometry Overlay

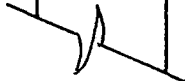
Matrix Size	Matrix	Description
NACP X IPSIZE	$[\phi_{CP}]$	Modal deflections at control points
NACP X IPSIZE	$[\phi'_{CP}]$	Modal slopes at control points
NAFP X IPSIZE	$[\phi_{FP}]$	Modal deflections at force points
	EOF	
		The three matrices are repeated per partition of the total number of modes with $IPSIZE \leq 20$

Figure 37. — S1L217 Logical File 2 After Overlay (L217,3,3), FLXMOD

Matrix Size	Matrix	Description
NSBCP X IPSIZE	$[\phi_{CP}]_{SB}$	Modal deflections at SB control points
NSBCP X IPSIZE	$[\phi'_{CP}]_{SB}$	Modal slopes at SB control points
NSBCP X IPSIZE	$[\phi''_{CP}]_{SB}$	2nd deriative of modal deflections at SB control points.
NTBCP X IPSIZE	$[\phi_{CP}]_{TB}$	Modal deflections at TB control points
NTBCP X IPSIZE	$[\phi'_{CP}]_{TB}$	Modal slopes at TB control points
NAFP X IPSIZE	$[\phi_{FP}]$	Modal deflections at all force points
	EOF	The matrices are repeated per partition of the total number of modes with IPSIZE $\leq 20$

Figure 38. — S1L217 Logical File 2 After Overlay (L217,4,3), DLAMOD

Matrix Size      Matrix      Description

NSBFP2 X NSBFP	[CP <sub>SB</sub> ]	Slender body pressure coefficients	
NSBFP2 X NGCP	[CPG <sub>SB</sub> ]	Slender body gust pressure coefficients	
2 X NDOF	[W <sub>TB</sub> ]	Normalwash on thin body element 1	
2 X NGCP	[WG <sub>TB</sub> ]	Gust normalwash on thin body element 1	
2 X NDOF	[W <sub>TB</sub> ]		2
2 X NGCP	[WG <sub>TB</sub> ]		2
.	.		.
.	.		.
.	.		.
2 X NDOF	[W <sub>TB</sub> ] <sub>NTBFP</sub>	Normalwash on thin body element NTBFP	
2 X NGCP	[WG <sub>TB</sub> ] <sub>NTBFP</sub>	Gust normalwash on thin body element NTBFP	
EOF		Note: Because all of these	
		arrays are complex the	
		number of rows written	
		onto S1L217 were doubled.	

Figure 39. — S1L217 Logical File 3 After Overlay (L217,4,4), CPANDW

The card input data for all three aerodynamic paths is read from cards and stored on S1L217 in the same fashion. The file will contain the array {IBDTAB} for each thin or slender body specified by a card. The array {IBDTAB} contains seven elements:

Element	Description
1    ISY	= Interpolation surface number for the body's Y-motion (in the left most 30 bits)
ISZ	= Interpolation surface number for the body's Z-motion (in the right most 30 bits)
2    ISTORE	= Surface number in which the body's forces will be placed when written on EOMLOD
3    XSHIFT	} Geometric shift values
4    YSHIFT	
5    ZSHIFT	
6    NCS	= Number of control surfaces attached to the surface (= 0 for slender bodies and $\leq 10$ for thin bodies)
7    IBDTYP	= Body type code (1 = slender body and 3 = thin body)

If  $NCS > 0$ , the body table array will be followed immediately by NCS arrays {ICSTAB}. The {ICSTAB} will contain the numbers of the thin body elements contained in the control surface. Note that the elements are numbered relative to each thin body, not for the entire structure.

The S1L217 logical file 1 written by overlays (L217,3,2), FLXGEO  
(L217,4,2), DLAGEO  
(L217,5,2), DLPGEO

Although the geometry input data for the three aerodynamic paths is different, the geometry stored on the first logical file of S1L217 by the geometry processors is in exactly the same format.

Figure 36 displays the matrices written on the file. The following descriptions supplement the short ones in the figure.

#### {SURFTB}

Each element of SURFTB is an integer representing a modal interpolation surface used in L217 (EOM).

**SURFTB<sub>i</sub>** =  $10^6$  \* IS      Interpolation surface number  
                   +  $10^3$  \* ISTORE    Output surface number  
                   +  $10^2$  \* ITYPE    Body type code (1 = SB, 3 = TB)  
                   + 10 \* NMOT    Number of motion types for  
   Body (1 = TZ, 2 = TY, 3 = both)  
                   +        IPOS    Plane of symmetry code  
   (0 = off, 1 = on)

### **{IPNSRF} and {IPNSCP}**

Each element of IPNSRF/IPNSCP is an integer representing a force/control point.

**IPNSRF** =  $10^6$  \* IS  
                   +  $10^3$  \* ISTORE  
                   +  $10^2$  \* ITYPE  
                   +        IPOS

### **{RG}**

The gust rotation matrix has elements for all thin body and slender body control points.

For a thin body element:

Symmetric analysis  $RG_i = \cos\gamma_i$

Anti-symmetric analysis  $RG_i = -\sin\gamma_i$

Where  $\gamma_i$  is the element's dihedral angle

For a slender body element:

Symmetric analysis

Y-motion element  $RG_i = 0.0$

Z-motion element  $RG_i = 1.0$

Anti-symmetric analysis

Y-motion element  $RG_i = 1.0$

Z-motion element  $RG_i = 0.0$

### **[SIGMA]**

Each row *i* of [SIGMA] (also known as  $[\Sigma]$ ) indicates where the forces on aerodynamic element *i* are to be stored. The primary purpose of SIGMA is to add the interference body forces to the slender body forces. However, in the following paragraph, other factors are included in SIGMA for a FLEXSTAB AIC data case.

**SIGMA(i,1)** - Indicates which force point will receive the **SIGMA(i,2)** fraction of the force on aero element i

**SIGMA(i,3)** - Indicates which force point will receive the **SIGMA(i,4)** fraction of the force on aero element i

For a **FLEXSTAB** AIC data case, the following  $\Delta C_p$  factors are included in the second and fourth columns of **SIGMA**:

$\pi/2$  for slender body Y-motion elements

$-\pi/2$  for slender body Z-motion elements

-1.0 for interference body elements

1.0 for thin body elements

The **S1L217** logical file 2 written by overlays (**L217,3,3**), **FLXMOD**  
(**L217,4,3**), **DLAMOD**

The modal deflections and slopes calculated by **FLXMOD** and **DLAMOD** are written onto the second logical file of **S1L217**.

Overlay (**L217,4,4**), **CPANDW**, writes the intermediate arrays onto the third logical file of **S1L217** (fig. 39).

### **S2L217**

**S2L217** is written by overlay (**L217,2,0**), **STRUCT** (see fig. 40). It will contain the generalized structural matrices after **STRUCT** is finished. Actually, they are written in the secondary overlay, overlay (**L217,2,3**), **FORM13**. The matrices are written in the **READTP/WRTETP** format.

### **S3L217**

Overlays (**L217,3,4**), **FLXFRC**; (**L217,4,7**), **DLAFRC**; and (**L217,5,4**), **DLPFRC** all write the unsteady aerodynamic forces onto **S3L217** with the subroutine **WRTETP**. However, the exact content and format is different for each. **FLXFRC** output is displayed in figure 41. In **DLAFRC**, the entire logical file (including the end of file) is repeated for each frequency at which the aerodynamics are defined. Because the force matrices **[FR]** and **[FG]** are complex, they are written onto **S3L217** with **NAFP2** rows where **NAFP2 = 2 \* NAFP** (see fig. 42).

In **DLPFRC**, because the force matrices **[F<sub>12</sub>]<sub>k</sub>**; **k = 1, NFREQM** are complex, the matrix columns are written onto **S3L217** with **NAFP2** rows where **NAFP2 = 2 \* NAFP**. The columns of **[F<sub>12</sub>]<sub>1</sub>** are written first followed by the columns of **[F<sub>12</sub>]<sub>2</sub>**, etc. See figure 43.

### **NTP3**

**FORMWS** calls **WRTETP** to write the rows of **[W]**, the augmented normalwash, and **[WG]**; the augmented gust normalwash, onto **NTP3** (see fig. 44) as they are formulated. **FORMWS** later reads the rows back into core and writes the same data onto **NTP4** by columns with **FORTAN** unformatted write statements.

Matrix Size	Matrix	Description
NDOF X NDOF	$[M_1]$	Generalized stiffness matrix
1 X NDOF	$\circ$ $\{M_2\}^*$	Diagonal elements of the generalized damping matrix.
NDOF X NDOF	$[M_3]$	Generalized mass matrix
	EOF	* $M_2$ is present if and only if structural damping was specified with card 2.8.

Figure 40. - S2L217 After Overlay (L217,2,0), STRUCT

Matrix Size      Matrix      Description-----

NAFP X IPSIZE	$[F_1]_{IP}$	The real and imaginary parts of the aerodynamic forces.
NAFP X IPSIZE	$[F_2]_{IP}$	
		Repeat per modal partition; IP=1, NPARTS.
NAFP X 1	$\{FG\}_1$	The NGCP columns of the gust aerodynamic forces.
NAFP X 1	$\{FG\}_2$	
.	.	
.	.	
.	.	
NAFP X 1	$\{FG\}_{NGCP}$	
	EOF	

Figure 41. - S3L217 After Overlay (L217,3,4), FLXFRC

Matrix Size      Matrix      Description

NAFP2 X IPSIZE	[FR] <sub>IP</sub>	The aerodynamic forces on Thin and Slender Body force points. Repeat per modal partition; IP=1, NPARTS.
NAFP2 X 1	{FG} <sub>1</sub>	The NGCP columns of the gust aerodynamic forces on Thin and Slender Body force points.
NAFP2 X 1	{FG} <sub>2</sub>	
.	.	
.	.	
NAFP2 X 1	{FG} <sub>NGCP</sub>	
	EOF	

Figure 42. -- S3L217 After Overlay (L217,4,7), DLAFC

Matrix Size	Matrix	Description
NAFP2 X 1	$\{F_{12}\}_{1,1}$	Aerodynamic forces per generalized coordinate and per frequency.
NAFP2 X 1	$\{F_{12}\}_{1,2}$	
.	.	
.	.	
.	.	
NAFP2 X 1	$\{F_{12}\}_{1,NDOF}$	
NAFP2 X 1	$\{F_{12}\}_{2,1}$	
NAFP2 X 1	$\{F_{12}\}_{2,2}$	
.	.	
.	.	
.	.	
NAFP2 X 1	$\{F_{12}\}_{NFREQM,NDOF}$	
	ECF	

Figure 43. — S3L217 After Overlay (L217,5,4), DLPFRC

Matrix Size	Matrix	Description
-------------	--------	-------------

2 X NDOF	$[W]_1$	Augmented normalwash, row 1
2 X NGCP	$[WG]_1$	Augmented gust normalwash, row 1
2 X NDOF	$[W]_2$	2
2 X NGCP	$[WG]_2$	2
.	.	.
.	.	.
.	.	.
2 X NDOF	$[W]_{NBOX}$	Augmented normalwash, row NBOX
2 X NGCP	$[WG]_{NBOX}$	Augmented gust normalwash, row NBOX
EOF		Each row is written as a
		2 X N because the matrices
		are complex.

Figure 44. - NTP3 After Overlay (L217,4,5), FORMWS

SOLVDW calls the subroutine FUTSOL to solve the system of equations:

$$[D][\Delta_{cp}] = W/WG]$$

FUTSOL reads the right hand sides,  $[W/WG]$ , by columns from the file NTP4.

FUTSOL reads the D-quasi-inverse matrix in a variable number of records from the file NTP5.

FUTSOL writes the solution,  $[\Delta_{cp}]$ , by columns onto the file NTP3 (see fig. 45) with FORTRAN unformatted write statements. Note that the matrix is complex.

#### NTP4

Overlay (L217,4,5) FORMWS uses a FORTRAN unformatted write statement to write the columns of  $[W]$  and  $[WG]$  onto the file named NTP4 (see fig. 46).

e.g., For column J of  $[W]$  it uses:

```
WRITE (NTP4) (W(I,J), I = 1, NBOX)
```

Note that both matrices are complex.

#### NTP5

Overlay (L217,4,6), SOLVDW, calls the subroutine COPYDQ to read the D-quasi-inverse records from the file NAETP, and writes the identical records onto NTP5. SOLVDW then calls the subroutine FUTSOL to solve the system of equations:

$$[D][\Delta_{cp}] = [W/WG]$$

Copying the D-quasi-inverse to NTP5 allows FUTSOL to repeatedly reposition the file without destroying the sequential processing of the file NAETP.

For a description of the records comprised in the D-quasi-inverse matrix, see the description of NAETP in reference 4.

#### MT, NIN, NOUT, and NATAPE

The scratch files MT, NIN, NOUT, and NATAPE are defined, used, and released within the subroutine FUTSOL. No other routines write or read these files. All of them are written/read with FORTRAN unformatted write/read statements.

NIN contains a temporary copy of the solution columns.

MT, NOUT, and NATAPE contain modified versions of the right hand sides and the D-quasi-inverse trapezoidal matrix.

Matrix Size	Matrix	Description
NBOX X 1	$\{\Delta CP\}_1$	$\Delta C_p$ due to mode 1
NBOX X 1	$\{\Delta CP\}_2$	$\Delta C_p$ due to mode 2
:	:	:
:	:	:
NBOX X 1	$\{\Delta CP\}_{NDOF}$	$\Delta C_p$ due to mode NDOF
NBOX X 1	$\{\Delta CP\}_{GNDOF+1}$	$\Delta C_p$ due to gust on zone 1
:	:	:
:	:	:
NBOX X 1	$\{\Delta CP\}_{GNDOF+NGCP}$	$\Delta C_p$ due to gust on zone NGCP
	EOF	

Figure 45. — NTP3 After Overlay (L217,4,6), SOLVDW

<u>Matrix</u>	<u>Size</u>	<u>Matrix</u>	<u>Description</u>
NBOX X 1		$\{W\}_1$	Augmented normalwash, column 1
NBOX X 1		$\{W\}_2$	Augmented normalwash, column 2
:		:	:
NBOX X 1		$\{W\}_{NDOF}$	Augmented normalwash, column NDOF.
NBOX X 1		$\{WG\}_1$	Augmented gust normalwash, column 1.
:		:	:
NBOX X 1		$\{WG\}_{NGCP}$	Augmented gust normalwash, column NGCP
		EOF	

Figure 46. – NTP4 After Overlay (L217,4,5), FORMWS

## **Common Blocks**

Table 29 shows the common blocks used in the program and the overlays in which they are defined.

The labelled common blocks are used for communication between the primary and secondary overlays, and for communication between routines in a secondary overlays. The block names and contents are described in table 30.

Blank common is used as a variable length working area. In general, the main program of an overlay calculates the area required for arrays in the various subroutines and passes a dimension and first word addresses of the arrays through the subroutines' argument lists.

Table 29. — Common Blocks Defined in Each Overlay

OVERLAY \ COMMON BLOCK	AERFRQ	BODPAN	BUFF1	BUFF2	BUFF3	CHKPRT	CNSTNT	COMLOC	CRDING	CSFL	DAMPFL	DOF	DUBFLS	EOMTPS	FLXFLS	GRDPEN	HEADER	INOUT	KLOOP	MASSFL	MAXFL	NUMERR	OPTION	PARTS	PRINTO	RWBUFF	SATAP	SCRFIL	STIFFL	VARDIM	Blank
(L217,0,0)-L217									X		X						X	X				X	X	X			X	X		X	
(L217,2,0)-STRUCT						X			X	X	X	X					X	X			X	X	X	X			X	X		X	
(L217,2,1)-RSTRCT			X			X		X	X	X	X	X					X	X			X	X	X	X			X	X		X	X
(L217,2,2)-FORMAC			X	X		X		X		X	X	X					X	X			X	X	X	X			X	X		X	X
(L217,2,3)-FORM13			X	X		X				X	X	X							X		X	X	X			X	X		X	X	X
(L217,3,0)-FLXAIC	X	X	X			X	X				X		X	X	X		X	X	X			X	X	X	X		X	X			
(L217,3,1)-FLXCDS		X				X	X		X		X		X	X	X		X	X	X			X	X	X	X		X	X			
(L217,3,2)-FLXGEO		X		X		X					X		X		X		X	X				X	X			X	X				
(L217,3,3)-FLXMOD		X		X		X		X			X		X				X	X				X	X			X	X				
(L217,3,4)-FLXFRC	X	X		X	X	X	X	X	X		X		X		X		X	X				X	X	X	X		X	X		X	X
(L217,3,5)-FLXODR	X	X		X	X	X	X	X	X		X		X	X			X	X				X	X	X	X		X	X		X	X
(L217,3,6)-FLXEOM	X	X		X	X	X	X	X			X		X	X			X	X	X			X	X	X	X		X	X		X	X
(L217,4,0)-DLAIC	X	X	X			X	X				X	X	X	X	X		X	X	X	X		X	X	X	X		X	X			
(L217,4,1)-DLACDS		X				X	X		X		X	X	X	X			X	X				X	X	X	X		X	X			
(L217,4,2)-DLAGEO	X	X		X		X	X				X	X							X			X	X		X		X	X			
(L217,4,3)-DLAMOD		X		X		X		X			X		X						X			X	X		X		X	X			
(L217,4,4)-CPANDW	X	X				X	X	X			X		X						X	X		X	X	X		X	X		X	X	X
(L217,4,5)-FORMWS		X		X	X	X		X			X	X							X	X		X	X			X	X		X	X	X
(L217,4,6)-SOLVDW		X		X	X	X					X								X	X		X	X				X	X		X	X
(L217,4,7)-DLAFRC	X	X		X	X	X	X	X	X		X								X	X		X	X	X			X	X		X	X
(L217,4,10)-DLAODR	X	X		X	X	X	X	X	X		X			X					X	X		X	X	X			X	X		X	X
(L217,4,11)-DLAEOM	X	X		X	X	X	X	X			X		X	X			X	X	X			X	X	X	X		X	X		X	X
(L217,5,0)-DLPRES	X	X	X			X	X				X	X	X	X			X	X				X	X	X	X		X	X			
(L217,5,1)-DLPCDS		X				X	X		X		X	X	X				X	X				X	X	X	X		X	X			
(L217,5,2)-DLPGEO		X		X		X					X	X							X			X	X		X		X	X			
(L217,5,4)-DLPFRC	X	X		X	X	X	X	X			X	X							X			X	X	X	X		X	X		X	X
(L217,5,5)-DLPODR	X	X		X	X	X	X	X			X		X	X					X			X	X	X	X		X	X		X	X
(L217,5,6)-DLPEOM	X	X		X	X	X	X	X			X	X	X						X			X	X	X	X		X	X		X	X

*Table 30. - Contents of Common Blocks*

Each of the common blocks is described on a separate page. The following abbreviations are used to describe the individual variables.

NO. - indicates the variable number in the common block list.

VARIABLE - common block item name.

T - type of variable  
I = integer  
R = real  
C = complex  
H = hollerith

DIMENSION - number of elements in variable.

ENG. NOM. - engineering nomenclature - symbolic.

*Table 30. — Contents of Common Blocks*

<p>LABELED COMMON NAME: <u>AERFRQ</u></p> <p>DESCRIPTION: <u>Frequencies at which EOM will be defined</u></p>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	FREQM	R	20		Frequencies at which the aerodynamics are defined and for which the EOM are to be generated.

Table 30. - (Continued)

LABELED COMMON NAME: <u>BODPAN</u>					
DESCRIPTION: <u>Problem size in number of aero bodies and elements</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NBOD	I			Number of zero bodies (Thin and Slender)
2	NTB	I			Number of thin bodies
3	NIB	I			Number of interference bodies
4	NSB	I			Number of slender bodies
5	NSURF	I			Number of interpolation surfaces
6	NTBON	I			Number of thin bodies on the plane of sym.
7	NSBON	I			Number of slender bodies on the plane of sym.
8	NTBFON	I			Number of thin body elements on the P.O.S.
9	NSBON	I			Number of slender body elements on the P.O.S.
10	NTOTF	I			Number of force points total (NTBFP + NIBFP + NSBFP)
11	NTBFP	I			Number of thin body force points
12	NIBFP	I			Number of interference body force points
13	NSBFP	I			Number of slender body force points
14	NAFP	I			Number of aero force points (NTBFP + NSBFP)
15	NTOTC	I			Number of control points total (NTBCP + NIBCP + NSBCP)
16	NTBCP	I			Number of thin body control points
17	NIBCP	I			Number of interference body control points
18	NSBCP	I			Number of slender body control points
19	NACP	I			Number of aero control points (NTBCP + NSBCP)

Table 30. — (Continued)

LABELED COMMON NAME: <u>      BUFF1      </u>					
DESCRIPTION: <u>FIT and buffer arrays for a file created with</u> <u>FETAD.</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	FET1	R	35		the array used for a file's FIT and FET tables.
2	BUFF1	R	514		the array used for a file's I/O buffer.

Table 30. - (Continued)

<p>LABELED COMMON NAME: <u>      BUFF2      </u></p> <p>DESCRIPTION: <u>      FIT and buffer arrays for a file created</u>  <u>                  with FETAD.</u></p>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	FET2	R	35		the array used for a file's FIT and FET tables.
2	BUFF2	R	514		the array used for a file's I/O buffer.

Table 30. - (Continued)

LABELED COMMON NAME:   BUFF3  

DESCRIPTION: FIT and buffer arrays for a file created  
with FETAD.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	FET3	R	35		the array used for a file's FIT and FET tables.
2	BUFF3	R	514		the array used for a file's I/O buffer.

Table 30. -- (Continued)

LABELED COMMON NAME: <u>CHKPRT</u>					
DESCRIPTION: <u>Checkout print option</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ICKPRT	I			<p>Checkout print option            =0 No checkout printing requested            &gt;0 Intermediate checkout printing was requested.</p> <p>ICKPRT is redefined for each primary overlay.</p> <p>In STRUCT(L217,2,0) ICKPRT triggers the following:</p> <p>*1 Print message upon entering and leaving each secondary overlay and print[M<sub>1</sub>], [M<sub>2</sub>], and [M<sub>3</sub>] as generated.</p> <p>*3 Print items above plus in FORMAC(L221,2,2) print [CSDATA], {MCS}, [♦], [A], and [C].</p> <p>*5 Print items above plus a message from each VARDIM subroutine called.</p>

Table 30. - (Continued)

LABELED COMMON NAME: CNSTNT

DESCRIPTION: Numerical Constants used in program

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	RHO	R		$\rho$	air density
2	VEL	R		$V_T$	true air-speed
3	Q	R		q	dynamic pressure $q = 1/2\rho v^2$

Table 30. - (Continued)

LABELED COMMON NAME: <u>COMLOC</u>					
DESCRIPTION: <u>Indicate last VARDIM array located by the</u> <u>subroutine LOCATR.</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	JTHENT	I			Indicates the VARDIM array last located by a call to LOCATR.

Table 30. - (Continued)

LABELED COMMON NAME: CRDIMG

DESCRIPTION: Storage array for last card image.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ICARD	H	8		Array to contain the last 80-column card image read.
2	KEY	H			Keyword extracted from ICARD. KEY contains the first 4 characters of ICARD plus zero fill.

Table 30. -- (Continued)

LABELED COMMON NAME: <u>CSFL</u> DESCRIPTION: <u>Control surfaces adding freedoms</u> <u></u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ICSTPE	I			Name of the file containing the control surface data.
2	ICSFIL	I			Number of logical files on ICSTPE before the control surface data.
3	NCSEF	I			Number of control surfaces adding freedom.
4	NODMAX	I			Maximum number of nodes on the control surfaces.
5	NELE	I			Number of elements in [MCS].



Table 30. - (Continued)

LABELED COMMON NAME: <u>DOF</u>					
DESCRIPTION: <u>Number of degrees of freedom</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NDOF	I			Total number of degrees of freedom.
2	NDOFST	I			Number of structural degrees of freedom.
3	NDOFCS	I			Number of control surface degrees of freedom.
4	NTDEF	I.			Number of mode used in DLPRES to develop gust forces at non-zero frequencies.
5	NPDEF	I			Number of mode used in DLPRES to develop gust forces at a frequency of zero.

Table 30. - (Continued)

LABELED COMMON NAME: <u>DUBFLS</u>					
DESCRIPTION: <u>Define files containing Doublet Lattice Data</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NGETP	H			Name of the Doublet Lattice geometry data file.
2	IGCASE	I			Geometry case to be used.
3	NAETP	H			Name of the Doublet Lattice aerodynamic data file.
4	IACASE	I			Number of the Doublet Lattice data case to be processed.
5	IAERO	I			Option from Doublet Lattice =1 only the [D] and [F] matrices are on NAETP =2 only the [Q] and [C <sub>p</sub> ] matrices are on NAETP =3 [D], [F], [Q], and [CP] are on NAETP.

Table 30. - (Continued)

LABELED COMMON NAME: <u>EOMTPS</u> DESCRIPTION: <u>L217(EOM) output file names</u> <u></u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	EOMTAP	I			Name of the output equations of motion file.
2	EOMLOD	I			Name of the output force matrix file for loads.

Table 30. - (Continued)

LABELED COMMON NAME: FLXFLS

DESCRIPTION: Define files containing FLEXSTAB data.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	GDTAPE	H			Name of the file containing FLEXSTAB geometry data.
2	IGCASE	I			Number of data case on GDTAPE to be processed.
3	SDINDX	H			Name of the file containing the index of the FLEXSTAB SDSSTP file.
4	SDDATA	H			Name of the FLEXSTAB SDSSTP file, the file containing aerodynamic data.
5	IACASE	I			Number of the data case on SDINDX to be processed.

Table 30. - (Continued)

LABELED COMMON NAME: <u>GRDPEN</u> DESCRIPTION: <u>Define gradual penetration zones</u> <u></u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	XG	R	1		Gust reference point.
2	XGCP	R	NGCP		X-coordinates of gust control points.
3	XGLE	R	NGCP		X-coordinates of gust zone leading edges.

Table 30. - (Continued)

LABELED COMMON NAME: HEADER

DESCRIPTION: Header array to be written on the front of  
EOMTAP .

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION																																										
1	$\begin{Bmatrix} \text{HEAD} \\ \text{IHED} \end{Bmatrix}^*$	$\begin{Bmatrix} \text{R} \\ \text{I} \end{Bmatrix}$	30		<p>The header array to be written onto the beginning of EOMTAP.</p> <table><tr><th>Word</th><th>Content</th></tr><tr><td>1</td><td>7HDYLOFLX</td></tr><tr><td>2</td><td>Program name &amp; version</td></tr><tr><td>3</td><td>Date of run</td></tr><tr><td>4</td><td>NDOF</td></tr><tr><td>5</td><td>NLD</td></tr><tr><td>6</td><td>NPAN</td></tr><tr><td>7</td><td>NFREQM</td></tr><tr><td>8</td><td>Q</td></tr><tr><td>9</td><td>V</td></tr><tr><td>10-20</td><td>Future use</td></tr><tr><td>21</td><td>Null <math>[M_1]</math></td></tr><tr><td>22</td><td>Null <math>[M_2]</math></td></tr><tr><td>23</td><td>Null <math>[M_3]</math></td></tr><tr><td>24</td><td>Null <math>[M_4]</math></td></tr><tr><td>25</td><td>Null <math>[M_5]</math></td></tr><tr><td>26</td><td>Null <math>[M_6]</math></td></tr><tr><td>27</td><td>Null <math>\{C_2\}</math></td></tr><tr><td>28</td><td>Null <math>\{C_3\}</math></td></tr><tr><td>29</td><td>Null <math>[f_4]</math></td></tr><tr><td>30</td><td>Null <math>[\emptyset]</math></td></tr></table> <p>* The two arrays are equivalenced</p>	Word	Content	1	7HDYLOFLX	2	Program name & version	3	Date of run	4	NDOF	5	NLD	6	NPAN	7	NFREQM	8	Q	9	V	10-20	Future use	21	Null $[M_1]$	22	Null $[M_2]$	23	Null $[M_3]$	24	Null $[M_4]$	25	Null $[M_5]$	26	Null $[M_6]$	27	Null $\{C_2\}$	28	Null $\{C_3\}$	29	Null $[f_4]$	30	Null $[\emptyset]$
Word	Content																																														
1	7HDYLOFLX																																														
2	Program name & version																																														
3	Date of run																																														
4	NDOF																																														
5	NLD																																														
6	NPAN																																														
7	NFREQM																																														
8	Q																																														
9	V																																														
10-20	Future use																																														
21	Null $[M_1]$																																														
22	Null $[M_2]$																																														
23	Null $[M_3]$																																														
24	Null $[M_4]$																																														
25	Null $[M_5]$																																														
26	Null $[M_6]$																																														
27	Null $\{C_2\}$																																														
28	Null $\{C_3\}$																																														
29	Null $[f_4]$																																														
30	Null $[\emptyset]$																																														

Table 30. — (Continued)

LABELED COMMON NAME: INOUT

DESCRIPTION: STANDARD I/O Files

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	INFIL	I			Card input file (5)
2	IUTFIL	I			Printed output file (6)
3	IPFIL	I			Punched output file (7)

Table 30. — (Continued)

LABELED COMMON NAME: <u>KLOOP</u> DESCRIPTION: <u>Current Frequency</u> _____					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	IFREQM	I			Index indicating number of current frequency.
2	OMEGA	R			Current frequency in cycles/seconds.

Table 30. — (Continued)

LABELED COMMON NAME: <u>MASSFL</u> DESCRIPTION: <u>Storage location of [M]</u> <u></u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	MTAPE	H			Name of file containing [M], the generalized mass matrix.
2	MFILE	I			Number of logical files to skip before reading [M].
3	MMAT	I			Number of matrices to skip before reading [M].
4	MPRNT	I			Option requesting the printing of [M] if greater than 0.

Table 30. -- (Continued)

LABELED COMMON NAME: MAXFL

DESCRIPTION: Maximum Field Length

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	MAXFLP	I			Maximum field length used by the secondary overlay of a particular primary overlay.

Table 30. - (Continued)

LABELED COMMON NAME: <u>NUMEER</u> DESCRIPTION: <u>Count of fatal errors detected</u> <u></u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NERROR	I			Number of fatal errors detected and diagnosed by the program.

Table 30. - (Continued)

LABELED COMMON NAME: <u>OPTION</u> DESCRIPTION: <u>List of program options</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ISYM	I			Key indicating symmetric (ISYM=0) or anti-symmetric (ISYM=1) analysis.
2	IDAMP	I			Structural damping option (viscous damping, $M_2$ ), requested if IDAMP 0).
3	HALFUL	R			HALFUL=1. indicates [M] and [K] are for full airplane.  HALFUL=2. indicates [M] and [K] must be multiplied by 2.
4	NGCP				Number of gradual penetration control points (=1 means no gradual penetration) NOTE: (1≤NGCP≤35)
5	NFREQM	I			Number of frequencies at which aerodynamic data is defined (=0 means steady-state analysis is with KVALUE=0.)
6	IQUASI	I			Key requesting Doublet Lattice quasi-steady AIC solution if >0
7	ICENT	I			Key indicating that FLEXSTAB control points are at thin body box centers if ICENT=3. At control points if ICENT=0.

Table 30. - (Continued)

LABELED COMMON NAME: <u>PARTS</u> DESCRIPTION: <u>Describe modal data partitions</u> <u></u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NPARTS	I			Number of modal matrix partitions.
2	IPSIZ	I			Number of modes in all but last partition.
3	IPSIZE	I			Number of modes in last partition.

Table 30. - (Continued)

LABELED COMMON NAME: PRINTO

DESCRIPTION: Specify data to be printed

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	IPGEOM	I			=1, requests printing of geometry tables.
2	IPMODE	I			If =1 the interpolated mode shapes will be printed.
3	IPFORC	I			If =1 the force matrices written onto EOMLOD will be printed.
4	IPEQUA	I			If =1 the equations of motion matrices written onto EOMTAP will be printed.
5	IFREQP	I			Array indicating for which frequencies the force matrices and equations of motion will be printed.  If IFREQP(i)>0 print data for frequency i.

Table 30. - (Continued)

LABELED COMMON NAME: <u>RWBUFF</u>					
DESCRIPTION: <u>The buffer required by READTP</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	BUFSIZ	H	Variable		8HBUFSIZE
2	IBFSIZ	I			Length of BUFFRW
3	BUFFRW	R			Buffer array used by READTP to temporarily store an array read from a file.  The length of BUFFRW varies for each overlay in which it is used.

Table 30. - (Continued)

LABELED COMMON NAME: <u>SATAP</u> DESCRIPTION: <u>Storage location of SA arrays</u> <u></u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	SATAP	H			Name of the file written by L215 (MODINT) containing the modal interpolation information arrays - {SA}'s.

Table 30. - (Continued)

LABELED COMMON NAME: <u>SCRFIL</u>					
DESCRIPTION: <u>Scratch file names and last file used</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	S1L217	H			Name of an L217 scratch file (=6LSiL217)
2	LSTFIL	I			Number of last file written onto S1L217 by the STRUCT overlay.
3	S2L217	H			Name of an L217 scratch file (=6LS2L217)
4	S3L217	H			Name of an L217 scratch file (=6LS3L217)

Table 30. — (Continued)

LABELED COMMON NAME: STIFFL

DESCRIPTION: Storage location of [K]

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	KTAPE	H			Name of file containing [K].
2	KFILE	I			Number of logical files to skip before reading [K].
3	KMAT	I			Number of matrices to skip before reading [F].
4	KPRNT	I			Option requesting the printing of [K] if greater than 0.

Table 30. - (Continued)

LABELED COMMON NAME: <u>VARDIM</u> DESCRIPTION: <u>Accounting data for the VARDIM variable dimension</u> <u>array storage scheme.</u>					
NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NMAX	I			Maximum number of arrays to be defined with VARDIM.
2	NENTRY	I			Number of arrays currently defined.
3	LWAVAIL	I			Last word available in blank common.
4	LWUSED	I			Last word used by VARDIM in blank common.
5	LKAT	I			Pointer to the VARDIM KATLOG array in blank common (=1).
6	MAXUSD	I			Maximum core address used to store a VARDIM array during the current program's (overlay's) execution.

Table 30. — (Concluded)

LABELED COMMON NAME: Blank

DESCRIPTION: Variably dimensioned array storage

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	<div> <div>BLANK</div> <div>IBLNK</div> </div> *	<div>R</div> <div>I</div>	1		<p>The blank common array is loaded at the end of a program. The program uses the area between BLANK(1) and the end of field length for storage of variably dimensioned arrays - arrays with dimensions dependent upon the problem size.</p>

## **4.0 EXTENT OF CHECKOUT**

**Each module of L217 (EOM) was tested during development using numerical data cases which could be easily checked. The final version of the program was tested with a set of physically meaningful verification test cases. The verification cases and the options they exercise are displayed in table 31.**

**Boeing Commercial Airplane Company  
P.O. Box 3707  
Seattle, Washington 98124  
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Table 31. — Options Tested by Verification Data Cases

Case Value or Option	1 FLEXSTAB N5KA	2 FLEXSTAB N5KA Anti-Sym	3 DUBFLX N5KA	4 DUBFLX H7WC	5 DUBFLX N5KA	6 DUBFLX H7WC	7 DUBFLX N5KA Quasi- Steady	8 FLEXSTAB H7WC Document Sample Problem
NDOFST	5	5	5	2	5	2	5	2
NDOFCS	0	0	0	1	0	1	0	1
SYM/ANTI	SYM	ANTI	SYM	SYM	SYM	SYM	SYM	SYM
HALF/FULL	HALF	HALF	HALF	HALF	HALF	HALF	HALF	HALF
[M]	Cards	Cards	Cards	Tape	Cards	Tape	Cards	Tape
[K]	Cards	Cards	Cares	Tape	Cards	Tape	Cards	Tape
{g <sub>SD</sub> }	Cards	Cards	Cards	Cards	Cards	Cards	Cards	Cards
C.S. Freedoms	No	No	No	$T_z, \theta_y, \theta_x$	No	$T_z, \theta_y, \theta_x$	No	$T_z, \theta_y, \theta_x$
Aero Overlay	FLXAIC	FLXAIC	DLPRES	DLPRES	DLAIC	DLAIC	DLAIC	FLXAIC
NTDEF/NPDEF			1, 2	1, 2				
IQUASI	No	No			No	No	Yes	No
ICENT	3	3	1	1	1	1	3	1
Gust Zones	M, F, E*	M, F, E	M, F, E	M, F, E	M, F, E	M, F, E	M, F, E	M, F, E
Print			1, 2	1, 2	1, 2	1, 2		
Select Freq.								
Slender Bodies	2	2	3	1	3	1	3	1
Elements	12	12	9	10	9	10	9	10
Thin Bodies	3	3	3	4	3	4	3	2
Panels	10	10	10	16	10	16	10	16
Control Surface	No	No	No	No	No	No	No	1
Total Elements	40	40	43	62	43	62	43	62
Modes	5	5	5	3	5	3	5	3
Frequencies	1	1	2	2	2	2	2	1

\* M, F, E means Modes, Forces, and Equations of Motion.

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Volume 2	FLEXSTAB 1.02.00	User's Manual	NASA CR-114713
Volume 3	FLEXSTAB 1.02.00	Program Description	NASA CR-114714
Volume 4	FLEXSTAB 1.02.00	Demonstration Cases and Results	NASA CR-114715
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